
**A STUDY TO DETERMINE
OFF-OIL OPTIONS
FOR POND INLET, N.W.T.**

**with special emphasis on the prospects
for developing local coal reserves**



A STUDY TO DETERMINE OFF-OIL OPTIONS
FOR POND INLET, N.W.T.
with special emphasis on the prospects
for developing local coal reserves

By
Peter J. Poole

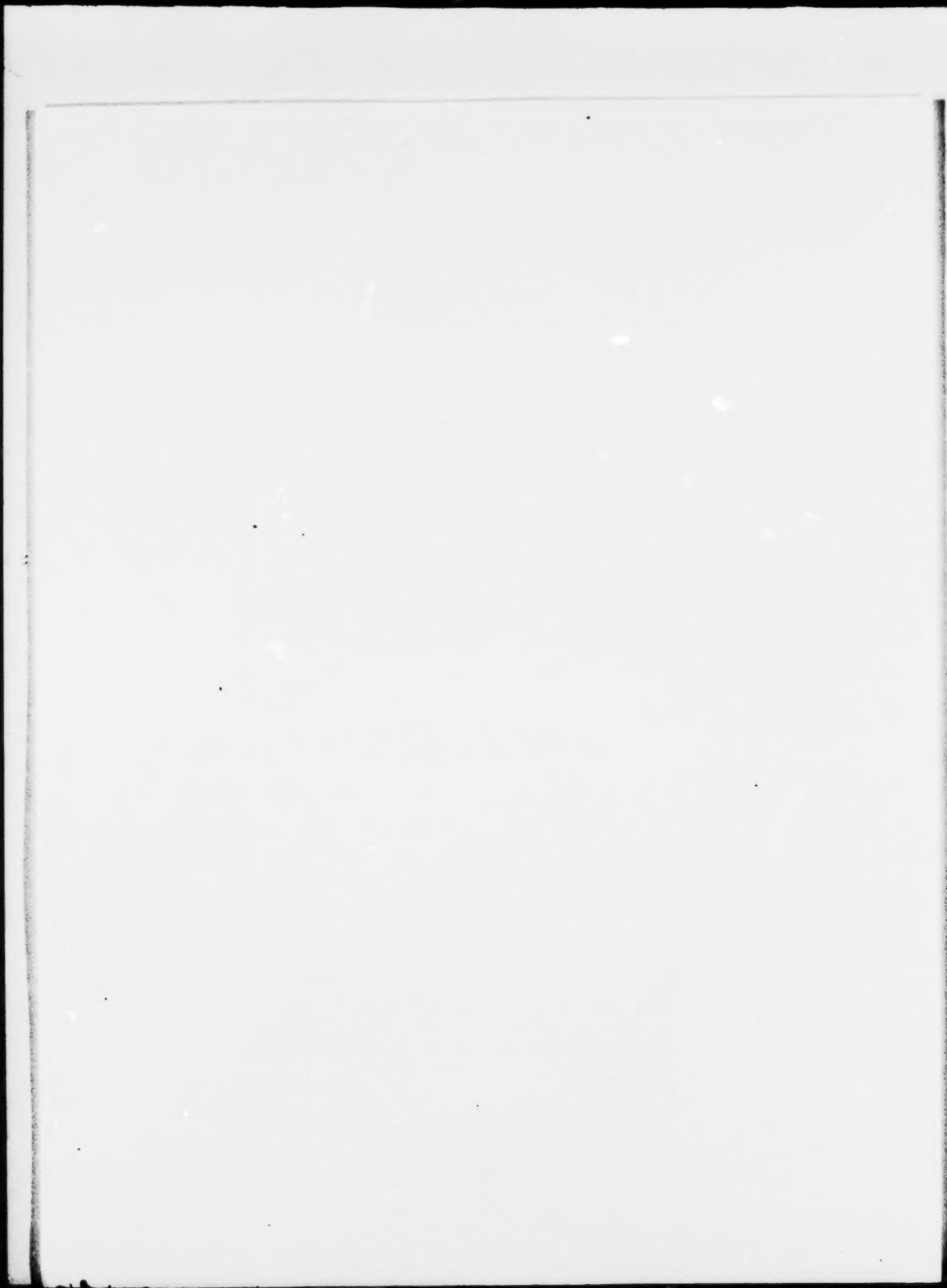
For
Pond Inlet Hamlet Council

Under
Remote Community Demonstration Program
Energy, Mines and Resources Canada

This report was prepared with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada (EMR). Distribution of this report by EMR does not necessarily signify that the contents reflect the views and policies of EMR. Mention of trade names and commercial products does not constitute recommendation or endorsement for use.

November 1983

RCDP/PDCE-10



CONTENTS

	<u>Page</u>
LIST OF TABLES.....	v
LIST OF MAPS.....	vi
LIST OF FIGURES.....	vi
FOREWORD: INFORMATION ON POND INLET.....	1
EXECUTIVE SUMMARY.....	6
CONCLUSIONS.....	11
RECOMMENDATIONS.....	12
RESUME POUR LA DIRECTION.....	13
PART I: CURRENT PATTERNS OF OIL PRODUCT CONSUMPTION AND THE EFFECTS OF ENERGY CONSUMPTION MEASURES.....	17
1.0. INTRODUCTION.....	17
2.0. CURRENT CONSUMPTION OF OIL PRODUCTS.....	18
2.1. Breakdown of consumption of all products for Pond Inlet.....	18
2.2. Notes on data sources and consistency.....	20
3.0. ENERGY CONSERVATION OPTIONS.....	30
3.1. Introduction.....	30
3.2. A district heating system based upon the use of waste heat.....	30
3.3. Programs to improve the energy efficiency of housing stock.....	35
3.4. The effects of the housing rehabilitation program upon the unit and overall consumption of energy.....	38
3.5. Projected reduction in domestic heating consumption once the rehabilitation and retrofit programs are completed.....	44
4.0. ENERGY ALTERNATIVES TO BOTH OIL AND COAL.....	46
4.1. Wind.....	46
4.2. Natural Gas.....	46
4.3. Slowpoke Nuclear Reactor.....	46

PART II: -COAL DEVELOPMENT

1.0.	INTRODUCTION TO PART II.....	47
2.0.	INVENTORY OF COAL RESERVES.....	48
2.1.	Geological Surveys.....	48
2.2.	Results of previous analyses of coal samples...	48
3.0.	COAL EXTRACTION METHODOLOGY.....	49
4.0.	COAL TRANSPORTATION.....	50
5.0.	COAL COMBUSTION TECHNOLOGY.....	51
5.1.	Introduction.....	51
5.2.	Coal-fired Space Heating.....	52
5.3.	Combustion Systems for Generating Electricity From Coal.....	54
5.4.	Stoker Technology.....	55
5.5.	Fluidized Bed Combustion.....	56
6.0.	ENVIRONMENTAL IMPACTS OF COAL DEVELOPMENT.....	57
7.0.	THE SOCIO-ECONOMIC COST/BENEFIT OF COAL DEVELOPMENT.....	60
8.0.	COAL DEVELOPMENT SCENARIOS.....	62
9.0.	THE SCOPE FOR INFORMATION TRANSFER OF THE RESULTS OF THIS STUDY TO OTHER REMOTE COMMUNITIES.....	64
	LIST OF APPENDICES.....	65

LIST OF TABLES

	<u>Page</u>
1. Background Data on Energy Consumption by Houses: Unit Numbers, Lot Numbers, Heating Fuel Consumption, Electricity Consumption, Conservation	22
2. Energy Consumption by Major Users and User Groups.....	26
3. Fifteen Highest Consumers of Heating Fuel: Single Buildings Only.....	32
4. Ratios Between Sample District Heating Pipe Layouts and the Heating Loads Displaced.....	34
5. Schedule of Rehabilitation and Retrofits for Buildings Operated by the Housing Association.....	36
6. Energy Consumption in Relation to Rehabilitation Program.....	40
7. Average Heating Fuel and Electricity Consumption by Housing Stock Type.....	41
8. Costs of Heating Fuel and Electricity by Housing Stock Type.....	43
9. Projected Reduction in Domestic Heating Fuel Consumption Once Rehabilitation and Retrofit Programs are Completed.....	45
10. Employment Prospects in Relation to Various Coal Development and Conservation Options.....	61

LIST OF MAPS

	<u>Page</u>
1. North Baffin Region: Location of Pond Inlet.....	4
2. Local Area: Pond Inlet - Salmon River.....	5
3. Distribution of Heating Fuel Consumption by Building.....	28
4. Distribution of Electricity Consumption by Building.....	29
5. Sample District Heating Pipelines Connecting Sixteen Major Consumers of Heating Fuel.....	33
6. Conservation Status of Housing Association and Government of the Northwest Territories Stock.....	37

LIST OF FIGURES

FIGURE 1	POND INLET CONSUMPTION OF OIL PRODUCTS.....	18
FIGURE 2	PRINCIPAL USES FOR HEATING FUEL WITHIN THE COMMUNITY.....	19
FIGURE 3	COMPARISON OF HEATING FUEL AND ELECTRICITY BY HOUSING STOCK TYPE AND CONSERVATION STATUS.....	42
FIGURE 4	PRELIMINARY ENVIRONMENTAL IMPACT MATRIX FOR POND INLET COAL DEVELOPMENT OPTIONS.....	59

FOREWORD

POND INLET

Location: North end of Baffin Island, Eastern Arctic, N.W.T.,
72°41 minutes North, 78°00 minutes west.

Climate: Average Temperature: July - high 8.8°C.
January - high -27°C, low -35°C.

Precipitation: Rainfall 72.9 mm; snowfall 80.6 mm.
Prevailing Winds: Northwesterly at 13 knots

Natural Resources:

Barren Ground Caribou
Polar Bear Quota for Pond Inlet: 12
Ringed, Bearded, and Harp Seals
Walrus
Narwhale Quota for Pond Inlet: 100
Ptarmigan
Arctic Hare
Arctic Char
Snow Geese
Common Murre

Communications

Air postal service: twice weekly
Bell Satellite telephone (direct dialing)
CBC Satellite television (8:30 am - 1:00 am daily)
CBC Satellite FM radio (6:00 am - 2:00 am daily)
CBIK: Local AM radio - noon 12:30, 5:00 - 5:30, 9:00 - midnight.

Transportation

Air services: First Air - Hawker Siddeley 748 - Clyde, Broughton,
Pangnirtung, and Frobisher Bay, Tuesday and Thursday,
reversed Monday and Wednesday.
First Air - Delta Villand Twin Otter - Hall Beach,
Igloolik, Nanisivik, Monday
Ken Borek Ltd.: Connections with Arctic Bay and
Resolute - Thursday
Bradley Chartered Services Ltd.: by charter only

Sea: Canadian Coast Guard - yearly sea-lift
Local Outfitters: chartered services - small sea
craft

Land: Skidoos, walking, ATC

Population: 790

Language Spoken: Inuktitut and English

Local Government Structure:

Status: Hamlet
Mayor: Paniloo Sangoya
Deputy Mayor: Sam Omik
Secretary-Manager: Simon Merkosak
Assistant Secretary-Manager: Paul Koolerk

Community Organizations:

Local Education Society
Health and Alcohol Education Committee
Amoutik Day Care Group
Hunters' and Trappers' Association
Anglican Vestry
Hamlet Council
Co-op Board of Directors
Housing Association
Pond Inlet Volunteer Firefighters
Women's Auxiliary
Land Claims Committee

Churches

St. Timothy's Church (Anglican): Reverend J. Bell
Church of the Sacred Heart (Roman Catholic): Friar G.M. Rouselliere

Education Facilities:

Takijualik School: N. McDermitt
Adult Education Centre: E. Erkloo and L. Arreak - Adult
Educators, M. Love - Home Management Educator, S. Monteith
Secretary Treasurer

Medical Facilities

Nursing Station: 2 nurses, 1 dental therapist

Recreation Facilities

Mittima Hall
Takimualuk School Gymnasium

Local Business

Tahoonik-Sahoonik Co-operative: hotel restaurant, retail store, video arcade, fishing camp, fuel oil delivery, Atmospheric Weather Service weather station, Yamaha Snowmobile and Mariner Outboard Motor Dealer, outfitter.

Hudson's Bay Company: retail store

Outfitters: Titus Alloofoo, Paul Idlout, and Elijah Kadloo

Steltner Manufacturing Development: ice survey and oceanography studies

Northern Canada Power Commission

Hunters' and Trappers' Association: retail store with country food

Ski-doo shop: snowmobile engine body repair

Other Employers

Hamlet of Pond Inlet: Municipal Services

Government of the NWT: Departments of Education, Public Works, Fish and Wildlife, Health and Welfare, Social Services and the Executive.

Government of Canada: Departments of National Health and Welfare - Nursing Station, Justice - Royal Canadian Mounted Police, Fisheries and Oceans.

Arctic Personnel Ltd. Pan-Arctic Recruiting

First-Air: Agent

Kenn Borek Air Ltd.: Agent

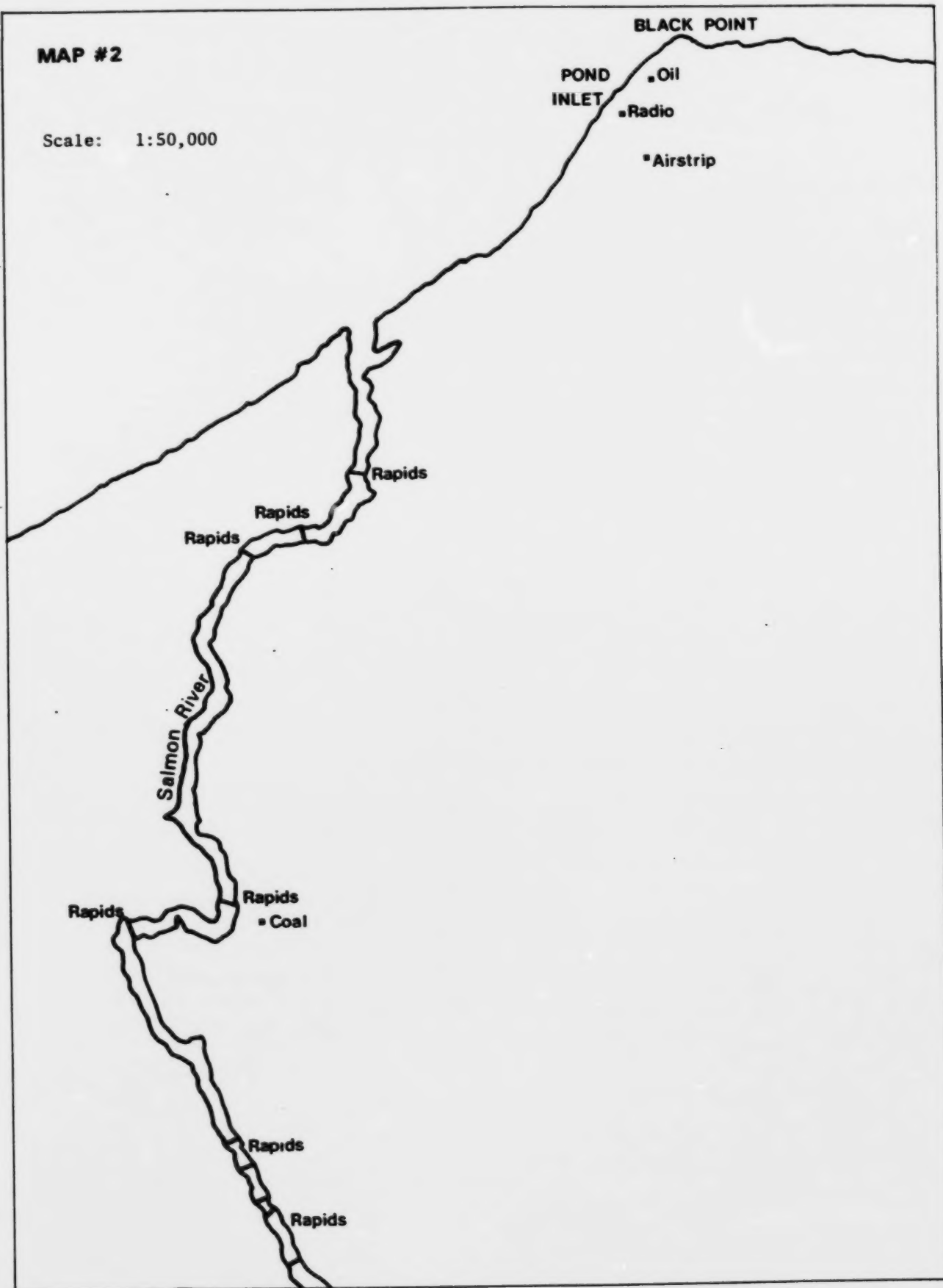
Bradly Chartered Services Ltd.: Agent

Housing Association



MAP #2

Scale: 1:50,000



EXECUTIVE SUMMARY

This project was executed by the Pond Inlet Hamlet Council, under an agreement with Energy, Mines and Resources Canada, and funded by the Remote Community Demonstration Program. The consultant was Peter J. Poole, Ph. D.

In seeking an evaluation of the feasibility of developing local coal reserves as a community energy source, the Council wishes not only to increase local energy independence but also to develop local employment and small business opportunities.

However, under the terms of the Remote Community Demonstration Program, it was felt that the coal feasibility study should be accompanied by an investigation of the extent to which local oil product consumption could be reduced through the implementation of conservation measures. Accordingly, the study report is presented in two parts; one dealing with energy conservation options, the other with the prospects for coal development.

Part I: Energy Conservation Options

Of the total volume of imported oil products, 70% is used for space heating (45%) and power generation (25%). The total volume of heating and generating oil, 2,000 litres, costs approximately \$2,000.00.

Of the 1,300,000 litres of heating fuel, 49% is used for residential heating. The main school building uses 16% and is one of 15 non-residential, single building consumers which take a total of 570,000 (44%) of the community heating fuel consumption.

The community consumption of electricity is 1,800,000 KWH's, and is divided into 1,300,000 KWH's (72%) for household use and 500,000 KWH's (28%) for non-residential uses.

At current rates of 51¢/litre and 31¢/KWH, the total annual household utilities costs are estimated at \$1,050,000, averaging at \$4,600 for heating and \$2,800 for electricity.

The potential for developing a district heating system using waste heat from the power station appear to be concentrated in one of two major clusters of buildings: 1) the six garages close to the station, and 2) the school, and several buildings between the school and the power station. The garage cluster consumes 10% of the community heating fuel and the school cluster consumes 18%. A system to heat both groups would reduce the community heating fuel by 28%.

The 111 houses administered by the Pond Inlet Housing Association are subject to a program of rehabilitation and retrofit which will terminate in 1989. Nine 'matchbox' types of housing stock have been designated as 'beyond repair', 50 will be rehabilitated, 42 will be retrofitted and 10 are regarded as 'conservationally acceptable'.

Rehabilitation involves both increasing energy efficiency and upgrading the amenities of the houses by installing flush toilets, running water, pump-out sewerage, and services for heavy-duty electric appliances. Retrofit involves only replacing leaking roofs with heated attics, an operation which is expected to improve heating efficiency by at most 15%.

The response to rehabilitation varied widely with the type of housing stock. With model 455 units, average heating fuel consumption declined from 4,900 litres to 1,500 litres per annum. With model 436/439 units, average annual consumption fell from 7,000 to 4,000 litres.

Rehabilitation appears to have an effect of equivalent significance upon the consumption of electricity: With model 436/439 units, electrical consumption doubled; with model 455 units, electrical consumption was halved.

The increase may be explained by the provision for major electrical appliances which is a component of the total rehabilitation package.

This is supported by the fact that the electrical consumption of rehabilitated 436/439 units is similar to that for the new Weber and Woolfenden houses, which come already equipped to accommodate major electrical appliances.

In this context, the decrease in electrical consumption in rehabilitated 455 units cannot be easily explained. However, the sample was small (10) and it is conceivable that these rehabilitations did not make provision for major appliances.

The prevailing view of government officials responsible for housing and energy programs is that rehabilitation does result in a significant increase in electrical consumption. What this study indicated is the extent of that increase in certain cases. This could have definite significance in relation to the objectives of the Remote Community Demonstration Program.

On a community basis, the volume of heating oil imported is about double that of generating fuel. In many of the advanced or rehabilitated houses, the diesel fuel equivalent of the electricity consumed is higher than the amount of heating oil used. This ratio is obscured by the average figures for domestic consumption of both oil products. These reflect the large proportion of older houses with high heating and low electricity costs. The trend, resulting from the introduction of advanced housing and the rehabilitation of older units, appears to be towards an increasing consumption of generating fuel which tends to neutralize the gains achieved through thermal performance upgrading.

For example, the average electrical consumption of a Woolfenden unit represents 5,000 litres of diesel fuel, while the average heating oil consumption is 3,500 litres (the average heating consumption for all houses is 4,500 litres). For the 42 Weber units in Pond Inlet, electrical consumption represents 5,000 litres/unit of diesel fuel, with heating oil consumption roughly equivalent of 5,000 litres (these houses are not slated for rehabilitation and will only derive minor increases in energy efficiency from retrofits - 15% estimated).

An attempt was made to estimate the effect that current conservation programs, rehabilitation and retrofit, will have upon the total community consumption of oil products. The results indicated that, when rehabilitation of all Housing Association units are finished, the community heating oil consumption will fall by 9%; if all other houses in the community receive similar attention, the eventual effect would be to reduce consumption by a further 2%. A similar estimate could not be made for electrical consumption because of the anomalous results obtained on the comparative response of 455 and 435/439 types of rehabilitation.

Projections of Pond Inlet housing needs for the period scheduled for the rehabilitation and retrofit programs vary between increases of 32% and 46% over present stock. Even the low increase would offset the reductions in community consumption of heating oil produced by the current energy conservation efforts.

Part II: Coal Development

Inspection of historical records of coal sample analysis and two analyses of casual samples taken during this study, indicate that, though the coal may be suitable in terms of combustibility, the variation in the content of certain elements, especially sulfur, is such that decisions over the most suitable coal conversion technology cannot be made until a more systematic inventory and quality assessment is completed.

It appears likely that economies of scale and power generation from coal will have a severely limiting effect upon the choice of suitable technology. The higher the demand for electricity, the more likely that an economical generation facility can be designed. This may argue in favour of using electricity for space heating.

A second overriding condition affecting coal development is the question of locating a generating station. The comparison of a mine site location versus a community location should be a major component in a future design study.

Several programs for an inventory of the reserves were produced during the study. Examination of the previous analyses of coal samples led to the need to know whether there are accessible deposits of limestone, to be used in the control of sulfur emissions. This objective must be considered in an inventory program.

The Salmon River deposits were examined. It appears that, if the extensions to the visible seams remain in the same relation to the surface, a simple open-pit operation would be sufficient to produce the coal.

Two routes between the community and the reserves were reconnoitered. There were few obstacles to the construction of an all weather road that could be used by 5 ton dump trucks.

Coal combustion technologies were examined under two main headings:

1) space heating, and 2) electricity generation. Space heating would be achieved either through a warm air or hot water circulation system in a district heating configuration. The generation of electricity would entail raising steam for turbines with the additional possibility of using hot gases to drive gas turbines.

Other methods of using coal as the energy base, liquifaction, gasification, or as a fuel when mixed with oil, were felt by the experts consulted to be too complex and expensive to contemplate for Pond Inlet at the present stages of technology development.

Most of the phases of coal combustion technology reviewed in this study are under constant improvement. Much of the research and development is directed to producing technology suitable for communities such as Pond Inlet, that is, small-scale automatic, and environmentally acceptable.

This applies to simple room-heaters as much as sophisticated power generating systems. The community would benefit by continuing to monitor developments in this field.

Since all domestic fuel costs are subsidized to some degree, and since even those paying the maximum still only pay a flat rate regardless of amount consumed, there is effectively no financial incentive for householders to switch from convenient oil-based systems to coal-fired systems requiring greater attention and carrying perhaps certain operational hazards. This situation is aggravated by the general recollection amongst older residents of coal-fired heaters that were considerably less efficient and more troublesome than those available today.

Amongst the larger consumers, government agencies and commercial organizations, these may be a greater incentive to cut fuel bills, through budgetary necessity. With 15 buildings accounting for about 40% of the community heating fuel bill, substantial reductions could be attained with a minimum of energy distribution installations.

Coal-fired heating systems for small office buildings, schools, and factories is one of the most promising areas of current research and development. Moreover, the researchers developing these systems have acknowledged that they must compete with other energy sources not only in cost but also in ease of operation. Automatic stoking, ignition, and de-ashing are now featured on commercially available systems.

Several examples of such state of the art systems are described in the text. Finally, details are provided of a complete house designed around a coal-based natural air circulation heating system.

The prospects for using emerging technology for power generation from coal are less immediate but may improve considerably within a few years. Experts consulted felt that two combustion systems hold most promise, and developments in both should be monitored, at least until the coal inventory is complete. These were: 1) conventional stoker systems, and 2) fluidized bed combustion.

Stoker technology is simple, proven, and reliable. Moreover, a certain amount of research and development is directed towards improving these well-tried methods still further. It was even suggested that the community look for an 'obsolete' stoker in a region where these have been replaced by large generating systems (in England, some stokers, once converted to oil-burning are now being re-converted to coal-firing). However, this technology is not capable of reducing sulfur emissions without the addition of complex and expensive scrubbing systems which not only require limestone but produce large quantities of sludge.

The principal advantage of fluidized bed combustion are: 1) low grade fuels can be burned efficiently, 2) inherent capacity to reduce sulfur emissions, 3) high heat production for raising steam, and 4) potential for driving gas as well as steam turbines to produce electricity. While a fluidized bed combustion facility might cost less than a stoker-scrubber combination, some form of crushing and cleaning technology might be needed to prepare the coal. Pressurized fluidized bed combustion may be especially suitable for generating electricity and a schematic of such a system is shown in the text.

While the precise environmental impacts of coal development cannot be evaluated until further specific commitments are made to mine development and combustion systems, some idea of likely impact is required before such commitments are made. As a starting point, a provisional environmental impact matrix was compiled. It identifies the kind, but not the degree, of likely impact produced by various approaches to coal development.

A similar approximation was developed for the socio-economic cost/benefit of coal development. Various approaches to coal development are annotated in terms of the kinds of jobs that might become available and whether it would be long or short term employment.

CONCLUSIONS

1. Reductions in the total residential heating fuel consumption as a results of current rehabilitation and retrofit programs are likely.
2. This reduction in community heating fuel consumption is likely to be offset by increasing total demand as projected housing units are added.
3. Rehabilitation of older housing stock improves thermal energy efficiency of these houses by a considerable margin and is reflected in reductions in heating fuel consumption of as much as 70%.
4. Rehabilitation programs include upgrading the amenities of the housing stock by introducing the capacity to use major electrical appliances. Thus, rehabilitation may precipitate higher electrical consumption. The diesel fuel equivalent of electricity exceeds the level of heating fuel consumption. A comparison of the generating and heating fuel consumption of the newer housing stock supports this conclusion.
5. If the ultimate objective is to reduce the level of oil product imports, then this trend towards an increased consumption of electricity should be given serious attention - despite the fact the community consumption of heating fuel is double that of diesel generating fuel.
6. A district heating system using waste heat from either diesel or coal generators should concentrate first amongst the ten major buildings which consume 28% of the community heating fuel. Any surplus could be directed towards a further five buildings, which consume 16%.
7. If the coal reserves are eventually found to be as close to the surface as they are at the Salmon River exposures, a relatively simple and inexpensive open-pit mining operation is feasible.
8. The terrain between Pond Inlet and the Salmon River does not contain any serious obstacles to constructing an all-weather road using the equipment already operated in the settlement. A delivery route by water would not be practical.
9. Given the history of coal-heating with old, inefficient and hazardous units, and given that fuel oil consumption is subsidized on a flat rate basis, there is little incentive for Pond Inlet to switch from oil to coal.
10. For the major institutional and commercial consumers, a switch would be more sustainable. Moreover recent advances in automated, safe, and environmentally acceptable heating units for large buildings promise the highest reduction in oil consumption for invested capital and effort.

11. For the generation of electricity from coal, current operational plants are too large for scaling down economically for Pond Inlet. However, current research and development may well produce suitable technology within a few years.
12. The choice for coal combustion technology will probably lie between fluidized bed combustion and a refined version of conventional stoker technology. The most critical factor in exercising this choice will be the results of an inventory of the coal reserves available to Pond Inlet.

RECOMMENDATIONS

1. That an inventory of the local coal reserves take place as soon as possible.
2. That an attempt be made to determine the cost effectiveness of a district heating system supplied by waste heat from the diesel generators.
3. That those major consumers not included in the district heating system be regarded as candidates for the demonstration of an advanced automated coal-heating system. A design study for this demonstration could commence immediately, though finalizing the plan should await the results of the coal deposit inventory.
4. That an attempt be made to determine the impacts upon domestic electricity consumption of both the rehabilitation programs and the introduction of advanced housing.

LES POSSIBILITES DE REMPLACEMENT DU PETROLE
A POND INLET (T. N.-O.)

et surtout la possibilité d'exploiter
les réserves locales de charbon

Résumé pour la direction

Cette étude a été effectuée par l'expert-conseil, Peter J. Poole, pour le Pond Inlet Hamlet Council, à l'aide d'une subvention du Programme de démonstration dans les collectivités éloignées d'Energie, Mines et Ressources Canada.

Du volume total de produits pétroliers importés, 70 % servent au chauffage (45 %) et à la production d'énergie (25 %). Le coût du volume total de combustible utilisé pour le chauffage et la production d'énergie, soit deux millions de litres, est d'environ 2 000 000 \$.

La collectivité consomme 1 300 000 litres de mazout dont 49 % servent au chauffage résidentiel. L'école consomme 16 % du volume total et elle est un des 15 immeubles non résidentiels qui utilisent 570 000 litres (44 %) du volume total de mazout.

Dans le cas de l'électricité, la collectivité consomme 1 800 000 kWh dont 1 300 000 kWh (72 %) dans le secteur résidentiel et 500 000 kWh (28 %) dans les autres secteurs.

Les prix actuels étant de 51 cents le litre et 31 cents le kilowatt-heure, les coûts d'énergie totaux des ménages sont estimés à 1 050 000 \$ par année, soit 4 600 \$ pour le mazout et 2 800 \$ pour l'électricité.

Les conclusions du rapport sont:

1. La diminution du volume total de combustible consommé dans le secteur résidentiel, en conséquence des programmes de rénovation et de réfection en vigueur, devrait se traduire par une baisse d'environ 10 % du volume total de combustible consommé dans la collectivité.
2. Cette diminution de la consommation de combustible dans la collectivité sera probablement atténuée par une hausse de la demande totale, en conséquence de la construction de nouvelles maisons.
3. La rénovation des maisons plus vieilles améliore leur rendement énergétique de façon considérable et cette amélioration se manifeste par une baisse du volume de combustible consommé pouvant atteindre 70%.



5

— — —

6

4. Toutefois, les travaux de rénovation comprennent aussi l'amélioration des commodités des maisons afin de permettre l'utilisation de gros appareils ménagers. Ainsi, les travaux de rénovation peuvent entraîner un accroissement de la consommation d'électricité au point où le volume de carburant diesel utilisé pour produire l'électricité est supérieur au volume de combustible utilisé pour le chauffage. Une comparaison des volumes de combustibles consommés, d'une part, pour produire de l'électricité et, d'autre part, pour le chauffage dans les maisons modernes confirme cette conclusion.
5. Si l'objectif ultime est de réduire des importations de produits pétroliers, il faudra étudier de près cette tendance vers une consommation accrue d'électricité, même si le volume de combustible utilisé pour le chauffage dans la collectivité est encore le double du volume de carburant diesel consommé pour produire de l'électricité.
6. Un projet de chauffage par flots grâce à la récupération de la chaleur dégagée par une génératrice diesel ou par une génératrice alimentée au charbon devrait d'abord être envisagé pour les dix principaux immeubles qui consomment 28 % du volume de combustible utilisé pour le chauffage dans la collectivité. Toute énergie thermique supplémentaire produite par des installations de ce genre pourrait servir à chauffer cinq autres immeubles qui consomment 16 % du volume total de combustible utilisé pour le chauffage.
7. S'il est éventuellement établi que les gisements de charbon sont aussi près de la surface que le sont ceux de la rivière Salmon, l'exploitation d'une mine à ciel ouvert sera probablement la méthode relativement simple et peu coûteuse qui conviendra le mieux.
8. Le terrain entre Pond Inlet et la rivière Salmon ne présente aucun obstacle majeur à la construction d'une route tous temps, au moyen de l'équipement déjà utilisé dans la collectivité. L'utilisation du cours d'eau pour le transport du charbon n'est pas possible.
9. Etant donné que la collectivité conserve le souvenir des vieux systèmes au charbon inefficaces et dangereux qui étaient utilisés pour chauffer les maisons et que le coût du combustible consommé est subventionné par le biais d'un tarif uniforme, les chefs de ménage sont donc très peu incités à remplacer le mazout par le charbon.
10. A l'exception des institutions et des immeubles commerciaux qui sont les principaux consommateurs, le remplacement du mazout par le charbon serait plus pratique. En outre, les progrès récents au niveau de la mise au point de systèmes automatisés, sûrs et acceptables sur le plan écologique, pour le chauffage de gros immeubles offrent les meilleures possibilités de diminution du volume de combustible consommé, compte tenu du capital investi et des efforts déployés.



11. Dans le cas de la production d'électricité à partir du charbon, les centrales exploitées à l'heure actuelle sont de trop grande envergure pour qu'il soit possible d'en réduire la taille de façon économique compte tenu des besoins de Pond Inlet. Toutefois, il est fort probable que les travaux actuels de R&D produiront des techniques appropriées dans quelques années.
12. Le choix de la technique de combustion du charbon à adopter sera probablement limité à la combustion sur lit fluidisé ou à une variante perfectionnée de la chaudière classique à grilles mécaniques. Le choix de technique sera déterminé par l'importance des réserves établies.

Les recommandations du rapport sont:

1. Déterminer le plus tôt possible l'importance des réserves de charbon.
2. Tenter d'établir l'envergure et la nature d'un système de chauffage par flots grâce à la récupération de la chaleur dégagée par les génératrices diesel.
3. Etudier la possibilité d'un projet de démonstration d'un nouveau système automatisé et alimenté au charbon pour chauffer les gros immeubles exclus du projet de chauffage par flots. Une étude préliminaire en vue de ce projet-pilote pourrait être entreprise immédiatement mais les travaux de planification ne pourront être achevés avant de connaître les résultats de l'inventaire des réserves.
4. Tenter de déterminer l'incidence des programmes de rénovation et de la construction de maisons modernes sur le niveau de consommation d'électricité dans le secteur résidentiel.

PART I

CURRENT PATTERNS OF OIL PRODUCT CONSUMPTION

AND THE EFFECTS OF ENERGY CONSERVATION MEASURES

1.0

INTRODUCTION

On July 4, 1982, the Pond Inlet Hamlet Council adopted a resolution calling for a thorough examination of the feasibility of using local coal as a substitute for imported oil. In taking this course of action, the Council had two principal objectives: to increase the economic independence of the community, and to provide a local source of employment and small business enterprises.

The coal reserves of interest to the Council lie about 10 km to the southwest of the community where they occur as a conspicuous sequence of seams exposed along cliffs bordering the Salmon River. These deposits have been known and utilized for several decades. They were exploited under lease by the Hudson's Bay Company, which, in the 1920's took fifty tons a year, some of which was exported to other trading posts in the North Baffin Region.

Until quite recently, coal-heating was common in the settlement of Pond Inlet. However, this has since been entirely replaced by heating fuel. The purpose of this study is not so much to revert to the previous system of space heating using coal, as to explore all the technological options for coal development and to what extent these can be adapted to meet Pond Inlet's needs. This investigation will be accompanied by an assessment of the extent to which Pond Inlet's consumption of imported oil for space heating and the generation of electricity may be reduced through the implementation of conservation measures.

If this preliminary inquiry into the prospects for coal development yields promising results, they should lead directly to a systematic inventory of the accessible coal reserves. This in turn, should lead to the planning of coal conversion design study.

In order to prepare the ground as thoroughly as possible for a coal inventory and design study, this report will conclude with a set of provisional scenarios which can provide a framework for future plans by eliminating the most impracticable options.

This report is presented in two parts. The first deals with current patterns of oil product consumption and attempts to determine to what extent these can be changed through the implementation of conservation measures. This should, in a sense, provide a profile of the future energy demands that would have to be met by coal development.

The second part deals with coal development and will review as many of the options as can be evaluated with the available information.

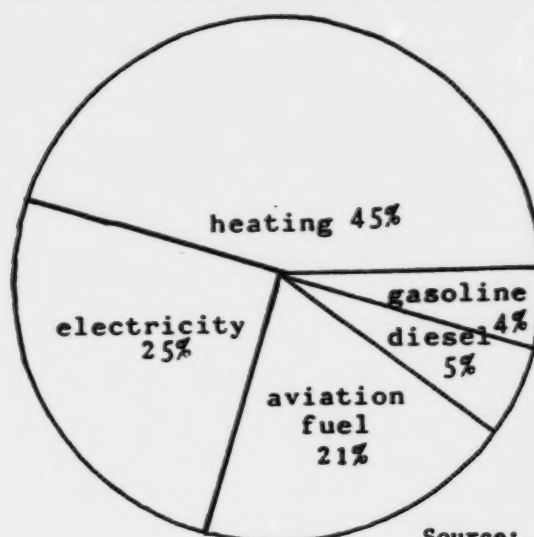
2.0 CURRENT CONSUMPTION OF OIL PRODUCTS

2.1 Breakdown of Consumption of all Products for Pond Inlet

Figure 1 illustrates the uses for all oil products imported into Pond Inlet. Three of these products will be excluded from this study - gasoline, used mainly for snowmobiles and trucks, diesel fuel, used for trucks and heavy equipment; aviation fuel, used principally for refueling the local commuter airline from Frobisher Bay.

Figure 1

POND INLET CONSUMPTION OF OIL PRODUCTS

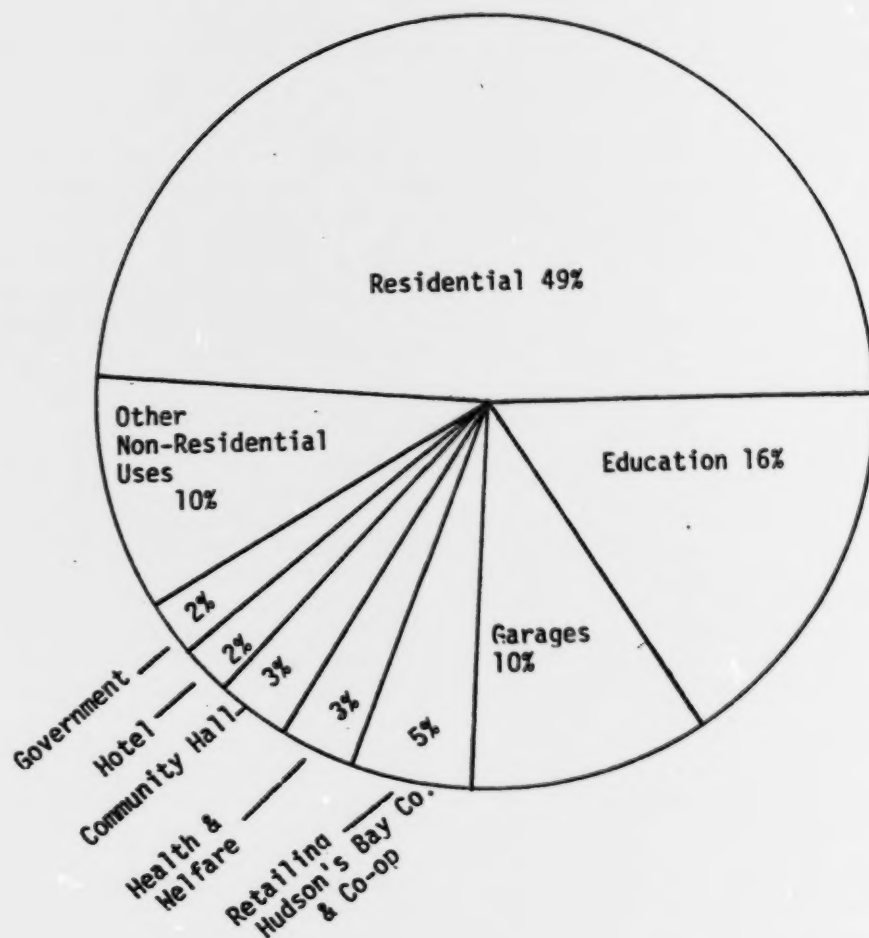


Source: Science Advisory Board 1981

This study deals with the 70% of oil products used for heating buildings and generation of electricity. Given that the total will vary from year to year, a working quantity of 2,000,000 litres has been estimated for heating and generating fuel combined: 700,000 litres (35%) for generating fuel and 1,300,000 litres (67%) for heating fuel (the reliability of these estimates is discussed below in the note on data consistency, section 2.2). The breakdown in use of heating fuel is fairly evenly divided between domestic heating and the heating of various government and commercial buildings. Figure 2 shows this breakdown in terms of major uses, rather than end users, within the community.

Figure 2

PRINCIPAL USES FOR HEATING FUEL WITHIN THE COMMUNITY



The data that was readily accessible on the building by building consumption of electricity was not so complete as to permit a comparable breakdown in terms of uses. However, the total community consumption of 1,800,000 KWH's seems to be less evenly shared, with 1,300,000 KWH's (72%) going to residential use and the remaining 500,000 KWH's (28%) to non-residential uses.

The prices paid by commercial interests for heating fuel and electricity are higher than those paid by other users and may be regarded as the closest approximation to the real costs of these utilities. In July, 1983, these were: 51¢/litre for heating fuel, and 31¢/KWH for electricity.

At these rates, the community heating and generating fuel bill exceeds \$1,000,000. The total costs of domestic heating and electricity amount to \$320,000 for heating and \$400,000 for electricity with the latter figure including the costs of converting diesel fuel to electricity and maintaining the local grid.

It is important to bear in mind the costs of heating and electricity at the domestic level. Given that the community consumption of heating fuel is about double that for generating fuel, it would seem that the most effective way to reduce total consumption would be to target heating fuel. However, the discussion in section 3 will indicate that, as household heating bills decline, electricity bills rise for reasons that have less to do with the mechanics of energy conservation than with the general increase in the level of household amenities and conveniences that are taking place throughout the Northwest Territories.

2.2. Notes on Data Sources and Consistency

Problems were encountered in obtaining uniform and comprehensive data on current patterns of oil product consumption. This was partially due to a multiplicity of recording and delivery systems and partially due to factors beyond the control of fuel supply systems, for example, the increased demand during exceptionally cold periods and the surpluses carried over after exceptionally mild periods. In combination, these factors can produce considerable variations over time.

For example, the figure given for the consumption of heating oil in the Science Advisory Board report provides a figure of 1,600,000 litres for annual domestic consumption of heating oil, yet the present study, based on the Petroleum, Oil and Lubricant Department's figures for 1982 and 1983, produced an estimate of about 1,300,000 litres. Furthermore, the Petroleum, Oil and Lubricant Departments records themselves contain certain inconsistencies, the 1982 figure for the heating fuel consumption of the main school building was 166,127 litres, and the comparable figure for 1983 was 65,063 litres - surely a larger difference than could be explained by climatic variation.

The Petroleum, Oil and Lubricant Departments sources also show, for consumption of generating fuel by the Northern Canada Power Commission, 706,637 litres in the 1982 summary and 12,148 litres in the 1983 summary. In this case, the figure of 700,000 has been taken as a working estimate for this study, as it closely coincides with the figure given in the Science Advisory Board Report.

Such variations in the major recording and delivery systems were reflected by more specific problems at the local level. Within the

community, there are several systems for identifying buildings: by lot number, by house number listed under the Housing Association, by house number listed under the Government of the Northwest Territories, in several cases by no house number at all. To confuse this further, both house and lot numbers are frequently changed as new houses are built or changed from one jurisdiction to another. Often these changes are not matched by an actual alteration of the number on the house itself so not even the house by house inspection throughout the community yielded comprehensive data on all buildings.

This produced problems in matching house numbers with records of the delivery of heating fuel and electricity. In the cases where satisfactory results could not be obtained, either estimates were made based on the performance by similar structures, or the datum was listed as 'not available'.

In some cases, records of deliveries had not been coded in any form other than the original delivery slips. Collating all of these proved to be more time-consuming than expected. For example, in order to obtain annual heating fuel consumption for the sixteen buildings operated by the Hamlet Council, (see Table 2), a day was required to sift through over a thousand delivery slips.

The tables, maps, and figures produced in the text are annotated wherever estimates had to be made as substitutes for concrete data. In cases where the information was not as precise as it could have been, conclusions are either qualified accordingly or kept at a level of generality consistent with the precision of the data base. In general, the information was adequate for a preliminary study such as this, though for more detailed work, such a design study for a district heating system, time should be allocated for lengthy examination and cross-checking of records from a variety of sources.

Table 1 contains a fairly consistent data set on domestic energy utilization. Table 2 contains comparable information on non-domestic energy use, but the data on the consumption of electricity is less extensive for these buildings.

In order to determine the distribution of heating fuel and electrical consumption throughout the community, the data entered in Tables 1 and 2 have been represented in Maps 3 and 4. These maps will be of value later in making a preliminary assessment of the prospects for district heating.

Table I

BACKGROUND DATA ON ENERGY CONSUMPTION BY HOUSES: UNIT NUMBERS,
LOT NUMBERS, HEATING FUEL CONSUMPTION, ELECTRICITY CONSUMPTION,
CONSERVATION PERFORMANCE

1	2	3	4	5	6	7
Unit Number	Lot Number	Heating Fuel 1000's litres	Electr- icity 1000's KWH's	Stock Type	Year Built	Conservation Status
R1-4	83	5.0	1.9	386	60	BR
R1-5	84	4.7	0.8	386	60	BR
R2-9	84	1.9	1.0	368	62	BR
R1-15	78	2.6	6.5	370	63	BR
R1-30	41	3.9	1.5	395	65	BR
R2-31	43	6.5	3.1	396	65	BR
R2-32	42	4.9	5.7	397	65	BR
R1-50	72	3.7	2.0	424	65	BR
R1-158	43/37	2.8	2.2	370	65	BR
R3-59	12	6.9	3.9	436	67	RH/83-89
R3-63	58-1	6.6	3.2	436	67	RH/83-89
R3-71	11	6.9	5.5	439	67	RH/83-89
R3-72	9	7.1	5.1	439	67	RH/82
R3-65	57-4	6.8	4.7	436	67	RH/83-89
R3-73	30	6.1	2.9	436	67	RH/83-89
R3-75	32	8.0	5.7	439	67	RH/82
R3-77	34	7.8	3.2	439	67	RH/83-89
R3-78	35	6.0	8.8	436	67	RH/83-89
R3-80	25	7.8	2.9	436	67	RH/83-89
R3-81	26	5.5	5.7	436	67	RH/83-89
P2-62	33	5.4	6.5	436A	67	RH/80
P2-64	58-1	5.0	6.5	436	67	RH/80
P2-66	37	4.1	6.9	436	67	RH/80
P2-68	14	3.8	5.1	436	67	RH/80
P2-69	13	3.7	8.3	436	67	RH/80
P2-74	31	5.2	7.9	439	67	RH/80
P2-79	24	5.3	18.8	439	67	RH/80
P2-94	29	4.5	5.0	439	67	RH/80
P2-113	162	3.1	6.0	436	67	RH/80
R3-83	28	7.7	4.6	436	68	RH/82
R3-84	1	7.3	2.3	439	68	RH/83-89
R3-85	6	7.4	3.7	436	68	RH/83-89
R3-86	5	5.8	4.1	439	68	RH/83-89
R3-87	4	6.9	2.4	439	68	RH/83-89

1	2	3	4	5	6	7
R3-88	3	6.4	3.8	439	68	RH/83-89
R3-89	2	7.3	3.1	439	68	RH/83-89
R3-67	101	7.4	1.3	436	68	RH/83-89
P2-114	162/17	5.4	12.1	436	68	RH/80
R3-62	27	9.2	4.7	436	68	RH/83-89
P3-95	106	1.8	3.6	455	71	RH/81
P3-96	111	1.7	5.5	455	71	RH/81
P3-97	109	1.8	3.6	455	71	RH/81
P3-98	107	1.4	1.9	455	71	RH/81
P3-101	112	1.4	3.1	455	71	RH/81
P3-102	105	1.0	4.5	455	71	RH/81
P3-103	110	1.2	3.6	455	71	RH/81
P3-104	104	1.4	4.1	455	71	RH/81
P3-105	113	1.7	3.4	455	71	RH/81
P3-106	114	3.5	9.6	455	71	RH/81
P3-108	116	5.9	6.7	455	71	RH/82
P3-109	117	6.1	2.9	455	71	RH/82
P3-110	119	4.6	5.1	455	71	RH/82
P3-111	120	3.7	6.0	455	71	RH/82
P3-112	108	1.2	3.1	455	71	RH/81
R3-118	145	3.5	13.2	455	73	RH/82
R3-116	124	4.3	7.3	455	73	RH/82
R3-117	144	4.7	6.4	455	73	RH/82
R3-60	71	5.2	8.2	455	74	RH/82
R3-61	81	6.0	7.5	455	74	RH/82

P4-132	132	6.1	11.1	We	75	RF
P4-133	133	5.0	11.6	We	75	RF
P4-134	134	5.6	14.4	We	75	RF
P4-139	139	8.1	14.6	We	75	RF
P4-140	140	6.7	11.3	We	75	RF
P4-141	141	8.4	10.4	We	75	RF
P4-142	142	8.6	17.1	We	75	RF
P4-143	143	8.0	16.6	We	75	RF
P3-7	7	7.4	14.1	We	75	RF
P3-8	8	7.5	14.4	We	76	RF
P2-70	70	5.2	8.8	We	76	RF
P2-76	76	5.2	17.5	We	76	RF
P3-90	90	5.7	11.6	We	76	RF
P2-99	99	1.0	11.9	We	76	RF
P2-123	123	5.5	14.1	We	76	RF
P2-135	135	5.5	14.4	We	76	RF
P2-136	138	5.8	11.3	We	76	RF
P2-138	149	6.9	14.2	We	76	RF
P2-149	149	5.7	10.7	We	76	RF
P2-150	150	6.9	13.5	We	76	RF
P4-151	151	5.6	15.3	We	76	RF

P4-152	152	6.8	11.8	We	76	RF
P3-153	153	1.4	11.7	We	76	RF
P4-100	100	5.9	8.2	We	77	RF
P4-119	124	6.5	8.7	We	77	RF
P4-120	137	4.0	14.1	We	77	RF
P2-137	137	3.9	13.0	We	77	RF
P3-155	155	5.1	20.0	We	77	RF
P3-156	156	4.0	16.6	We	77	RF
P2-157	157	4.4	14.4	We	77	RF
P2-159	159	3.6	14.4	We	77	RF
P3-144	144	5.6	12.0	We	77	RF
P3-10	10	4.4	12.8	We	78	RF
P3-18	18	4.6	12.7	We	78	RF
P3-20	20	4.6	14.9	We	78	RF
P3-21	21	3.8	13.2	We	78	RF
P3-22	98	4.5	13.0	We	78	RF
P3-23	97	3.6	17.0	We	78	RF
P3-24	96	4.8	14.1	We	78	RF
P3-27	74	3.9	13.0	We	78	RF

P4-121	159	5.8	20.9	Wo	79	CA
P4-122	159	4.5	15.1	Wo	79	CA
P4-124	160	5.7	14.9	Wo	79	CA
P2-125	A/60	2.7	12.9	Wo	79	CA
P2-126	B/60	2.1	13.7	Wo	79	CA
P2-127	160	1.1	15.7	Wo	79	CA
P4-128	A-160	2.5	7.8	Wo	79	CA
P2-129	B-160	4.1	11.6	Wo	79	CA
P2-130	A-167	3.0	12.4	Wo	79	CA
P2-131	B-167	3.8	8.9	Wo	79	CA

54001	--	3.7	9.2	N/A	N/A	NWTG House
54002	--	6.2	10.8	N/N	N/A	NWTG House
54003	--	4.2	9.7	N/A	N/A	NWTG House
54004	--	3.5	15.3	N/A	N/A	NWTG House
54005	--	2.0	8.3	N/A	N/A	NWTG House
54006	--	3.4	10.7	N/A	N/A	NWTG House
54007	--	3.5	9.0	442	N/A	NWTG House
54008	--	1.9	10.5	N/A	N/A	NWTG House
54009	--	4.3	9.0	We	N/A	NWTG House
54010	--	2.2	16.1	We	N/A	NWTG House
54011	--	2.9	12.5	We	N/A	NWTG House

Notes on Table 1

1. Heating fuel figures are taken from Petroleum, Oil and Lubricants computer printouts.
2. Electricity figures were taken from Regional Housing Association records.
3. The stock type numbers refer to the various house types introduced into arctic communities from the 1960's onwards. We denotes a Weber house; Wo denotes a Woolfenden house.
4. Under column 7, conservation status, the abbreviations refer to data collected from the Pond Inlet Housing Association. They refer chiefly to the status of the housing stock in relation to current and prospective improvement programs.

BR, means beyond repair under any program

RH/83-89, means slated for rehabilitation during period indicated.

RH/80, 81, or 82, means already rehabilitated in the year indicated.

RF, means slated for retrofit.

CA, means conservationally acceptable.

5. Data on the Government of the Northwest Territories housing was entered in this table as it was the only data set from the houses not under the jurisdiction of the Housing Association that could be compared in terms of heating fuel and electricity consumption.

TABLE 2

ENERGY CONSUMPTION BY MAJOR USERS AND USER GROUPS

User	Number of Units	Heating Fuel 1,000's litres	Electr- icity 1,000's KWH's	Comments
<u>GOVT. NWT.</u>				
School	1	166.0	77.2	
Arts & Crafts	1	22.5	13.4	
Adult Education	1	23.2	8.5	
Comm. Freezer	1	--	14.4	
Fish & Wildlife	1	8.4	4.3	
Garage	1	18.4	6.6	
Govt. Office	1	4.1	4.7	
Tank Farm	1	--	5.2	
Pump House	1	--	3.9	
Houses	13	44.1		
<u>POND INLET HOUSING ASSOC.</u>				
	111	524.9		
<u>HAMLET COUNCIL</u>				
Garage D119	1	20.6	--	
Garage D120	1	23.0	--	
Garage D12	1	26.0	--	
Garage No #	1	34.0	--	
Garage D-93	1	20.6	--	
Garage	1	5.8	--	
Warehouse D6	1	6.2	--	
Warehouse	1			
Community Hall	1	32.2	--	
Staff Houses	3	21.6	--	
Air Terminal	1			
Beacon	2			
Hamlet Office	1	25.2	--	

TAHOONIK -
SAHOONIK CO-OP

Store	1	32.2	49.5	
Hotel	3	27.0	52.6	Main building and two trailers
Weather Station	1	6.7	15.2	
Garage	1	18.8	4.2	Plus outbuildings

GOVT. OF CANADA

National Health & Welfare	4	39.1	--	Medical centre and three buildings
Fisheries & Oceans	1	1.5	--	
R.C.M.P.	6	31.8	--	Five buildings

OTHER MAJOR USERS

Anglican Mission	1	31.4	--	
R.C. Mission	1	8.6	--	
First air		32.9	--	
Steltner's	3	13.3	--	House and lab and small cool room
H.B. Company		51.7	--	3 buildings
Petro Canada	1	1.6	--	trailer

[illegible]

5. CONCLUSION

06/10/77

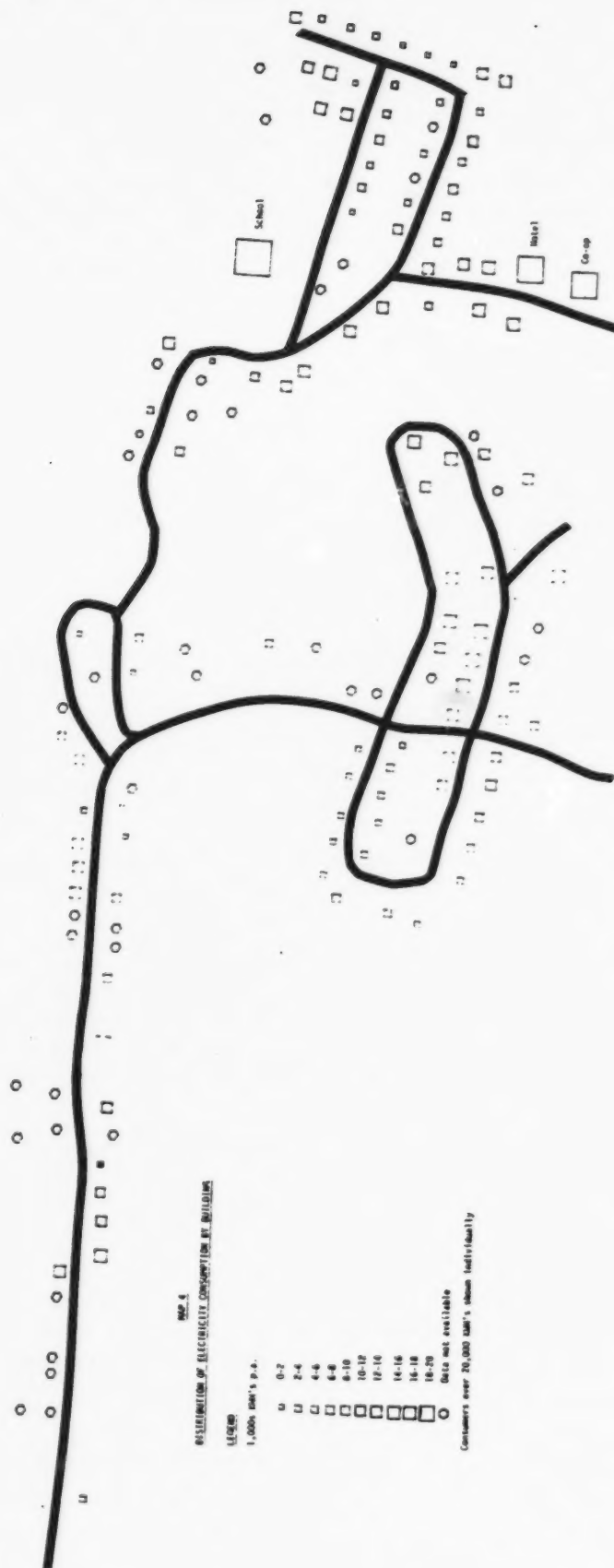
1,000's of litres p.d.

- 2 3 4 5 6 7 8 9 0
● ● ● ● ● ● ● ● ● ●

Data not available

Consumers over 20,000 litres than individually

MAP 4



3.0 ENERGY CONSERVATION OPTIONS

3.1 Introduction

Before considering in detail the question of coal development, a brief review is made of the extent to which the present energy production and distribution system could be improved through the implementation of appropriate conservation measures. Such an improvement could take two directions:

1) The use of waste heat from the diesel generating facility as the source for a district heating system, and 2) the reduction of demand for energy through improved conservation performance and practice in individual buildings.

Neither of these options would preclude the eventual use of coal instead of oil as a primary energy source; for example, if district heating proved feasible, the source could be either oil or coal produced waste heat. In fact a coal generating station could be relocated to maximize the opportunities for district heating.

3.2 A District Heating System Based Upon the Use of Waste Heat

In recent years, district heating systems have been installed in several Inuit communities: Cambridge Bay, Rankin Inlet, and Igloolik. In these settlements, available waste heat has not been sufficient for all buildings but has been directed towards major consumers located close to the generating plant.

The field data for this study was collected and organized so as to direct attention to the distribution of demand throughout the community and facilitate the evaluation of the prospects for a district heating system. It appears that such an assessment may be made independently of this study, using a computer program specifically designed for this purpose. However, this separate study had not been confirmed at the time the field data was collected. The cartographical analysis provided below is designed to show the location and concentration of heating loads through the community, in terms of the consumption of heating fuel by individual buildings.

In Map 3, residential use is shown in terms of ten levels of consumption, the highest of which is 9 - 10,000 litres per year (\$4,500 - \$5,000). Consumers above that level belong to the non-residential category and are shown individually.

In Table 3, the 15 highest consumers of heating fuel are listed as all those whose consumption exceeds 20,000 litres (\$10,000) per year. (First Air, with a consumption of over 30,000 litres has been excluded as most of the fuel used is for heating aircraft engines with Herman-Nelson heaters). These consumers, together with one small garage located close to the diesel generators, have been considered as candidates for a district heating system. The 16 buildings have been extracted from Map 3 and, in Map 4, shown in spatial relationship to the diesel generators.

The maps show demand to be concentrated firstly among the six garages close to the generating station and secondly at the main school buildings and adjacent government and school buildings. Two smaller clusters of major consumers stand in similar relation to these concentrations - the Tahoonik-Sahoonik Co-operative store and hotel beyond the school group, and the Community Hall/Hudson's Bay Store beyond the garage group.

Assuming that there is sufficient waste heat at source, a major factor in estimating the costs and efficiency of district heating systems is the length of heating pipe, as this entails capital and maintenance costs as well as a certain amount of heat loss. In map 5 the lengths of heating conduit required to displace the heating loads of these major consumers have been depicted. The conduit has been deployed without respect for existing roads and obstacles, but the purpose here is to obtain a first approximation of the efficiency of a district heating system.

This approximation has been represented in Table 4. This indicates that a line of 100 metres to garages A, B, C would displace a heating load represented by 65,000 litres. If this line is extended as far as the school, the load displaced increased to 301,200 litres and the ratio of heating load displaced improves to 771 litres for each metre of heating conduit. However, this large displacement would require 390 metres of pipeline, with consequent problems of heat loss.

A 116 metre line to the three garages, K, L, M would displace 80,600 litres of heating fuel at a high ratio in terms of the length of pipe used. A district heating system which deployed heat only to the six garages close to the generating station would require 216 metres of pipe and would displace 145,600 litres of fuel - 11% of the community bill for heating fuel. This could be achieved with the minimum impact upon existing infrastructure.

A further assessment of a district heating system would require a more detailed integration of the costs and volumes of waste heat available with the costs and efficiency of the distribution system. As mentioned above, such an analysis is being conducted under a separate study, which will provide data which may be used to refine the approximations arrived at here.

Such a further analysis would also have to take into account the fact that, if a coal generating station in the settlement proved to be a feasible proposition, that station could be located so as to maximize the opportunities for district heating, for example, close to the school, nursing station, and adjacent buildings.

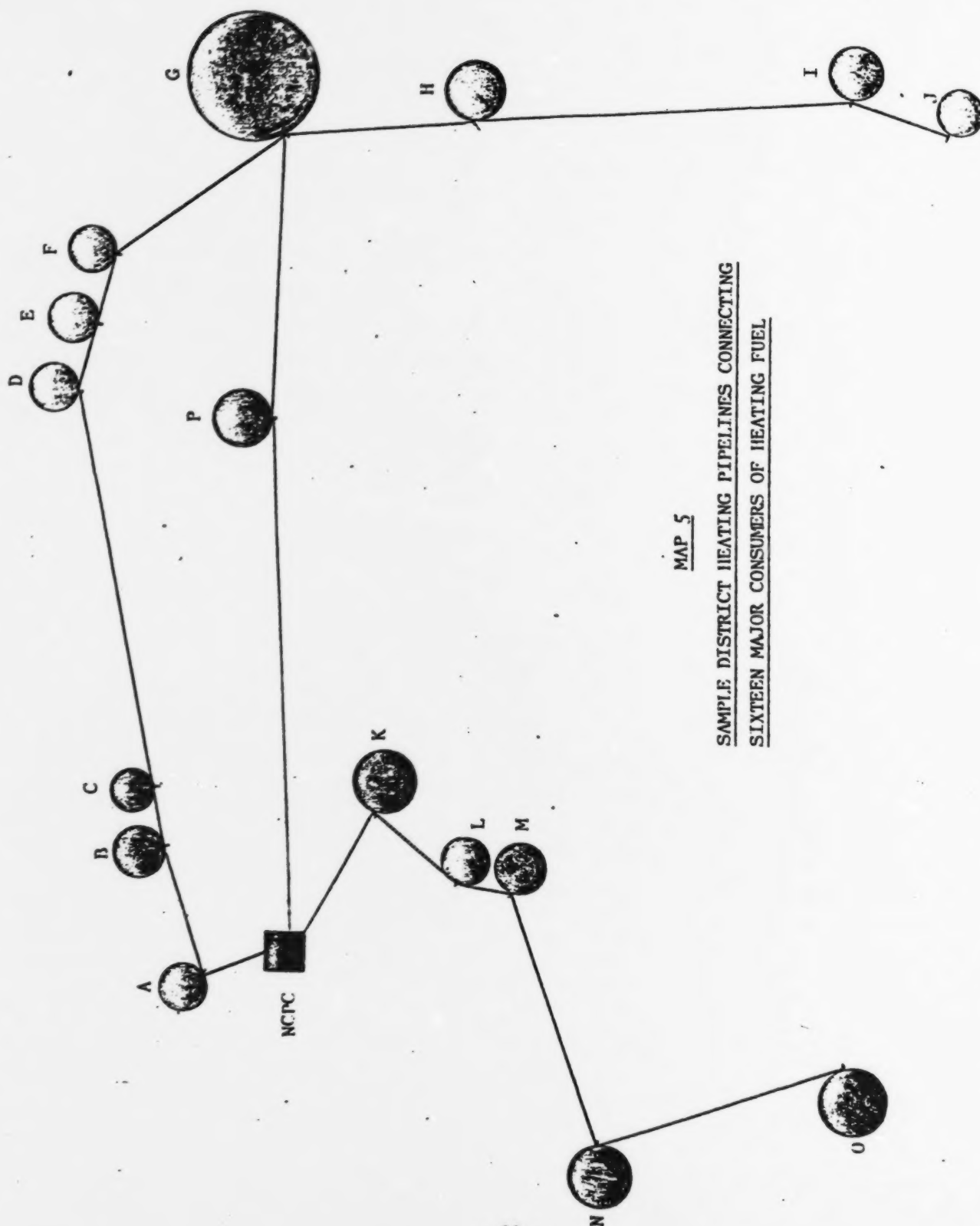
District heating systems in other areas have sometimes been integrated with other delivery systems as a means of reducing costs. In such systems, the utilidor carrying the heating pipe would also contain sewage lines, electrical cables and water pipes.

TABLE 3

FIFTEEN HIGHEST CONSUMERS OF HEATING FUEL

SINGLE BUILDINGS ONLY

UNIT	1,000 Litres p.a.	COMMENTS
School	166.0	Main building
Hudson Bay Company	40.0	Estimate for store and warehouse
Hamlet Council Garage	34.6	
Community Hall	32.2	
Nursing Station	32.1	Estimate for main building
Anglican Mission	31.4	
Tahoonik-Sahoonik Co-op Hotel	27.0	
Hamlet Council Garage	26.0	
Hamlet Office	25.2	
Tahoonik-Sahoonik Co-op Store	23.2	
Hamlet Council Garage	23.0	
Arts and Crafts Building	22.5	
Adult Education Building	22.5	
Hamlet Council Garage	20.6	
Hamlet Council Garage	20.6	



MAP 5

SAMPLE DISTRICT HEATING PIPELINES CONNECTING
SIXTEEN MAJOR CONSUMERS OF HEATING FUEL

Table 4

RATIOS BETWEEN SAMPLE DISTRICT HEATING PIPE LAYOUTS AND THE

HEATING LOADS DISPLACED

Buildings	Heating Loads	Cumulative Heating Loads	Length of Heating Pipe from Last Entry	Cumulative Length of Heating Pipe	Ratio: Heat Load Displaced to Length of Heating Pipe from Last Entry	Ratio: Heat Load Displaced to Length of Heating Pipe: Cumulative
	1000's litres	1000's litres	metres	metres	litres/ metre	litres/ metre
Garage A+B+C	65.0	65.0	100	100	650	650
Bldgs. D+E+F	70.2	135.2	210	310	334	436
School G	166.0	301.2	80	390	2,075	771
Nursing Station F	32.1	333.3	72	462	456	721
Co-op Store						
Hotel I+J	59.2	392.5	186	648	318	606
Garage K+L+M	80.6	80.6	116	116	694	694
Community Hall N	32.2	112.8	102	218	315	517
Hudson's Bay Store O	40.0	162.88	100	318	400	512
Anglican Mission P	32.1	32.1	198	198	162	162
School G	166.0	198.1	110	308	1,509	642

At present in Pond Inlet, those buildings with pump-out sewage systems are equipped with holding tanks which are evacuated on a regular basis by a sewage truck. Electricity is delivered by overhead cables throughout the community. Water is delivered by water truck to holding tanks inside the buildings.

Since only a minority of the buildings in Pond Inlet would probably benefit from a district heating system, an integration would not impede the cessation of existing services, in fact it would be likely to render them less cost-effective by reducing the level of demand. Though there may be scope for integrating electrical cable with district heating pipe, since it originates at the same Northern Canada Power Commission station, to achieve the same for water and sewage would require the placement of a small lagoon and holding tank close to the power station, and they would still ultimately require the attendance of the sewage and water trucks.

3.3 Programs to Improve the Energy Efficiency of Housing Stock

The conservation performance of housing stock in Pond Inlet has been inspected by the responsible agencies and programs for improving performance have been drawn up. Table 5 shows the program of retrofit and rehabilitation planned by the Pond Inlet Housing Association for the 111 units within its jurisdiction.

Nine matchbox types of housing were regarded as 'beyond repair'. These were constructed between 1960 and 1965, (see Table 1) and it was felt that neither upgrading their conservation performance nor their facilities as living quarters would be cost effective.

A program for rehabilitation has been laid out for the house types 436, 439, and 455. These were constructed between 1967 and 1974, contain 2 or 3 bedrooms and vary in area between 66 and 72 square metres. Most of these housing types were on 'partial services' (honey bucket, running water, sewerage pump-out) or 'no-services' (honey bucket, grey water discharge). Rehabilitation involves not only introducing 'full services' (flush toilets, running water, sewerage pump-out) but also improving the conservational efficiency by virtually re-building the shell of the house. Rehabilitation also entails raising the electrical entries into the houses.

Weber houses are regarded as satisfactory as far as their services and conservation performance are concerned but have all been slated for retrofit because the roofs of this type have been found to leak. The retrofit will entail roof renovation and an installation of heated attics. This is expected to improve conservation performance, though not dramatically. Through experience has yet to confirm this, informed opinion within the Government of the Northwest Territories has it that the maximum increase in heating efficiency would be 15%.

Comparable information on the conservation performance of other houses in the community could not be readily obtained. In some cases, such as the Hudson's Bay Company, the fuel bills for staff housing are merged into single organization accounts; in others, houses were unoccupied for much of the year and their fuel bills do not accurately reflect the conservational performance of the building. On the other hand, the records kept by the Pond Inlet Housing Association of most of the housing in the settlement provide consistent data for assessing the results of rehabilitation programs, and projecting the effects upon total domestic consumption once these are completed. This assessment is provided in the following section.

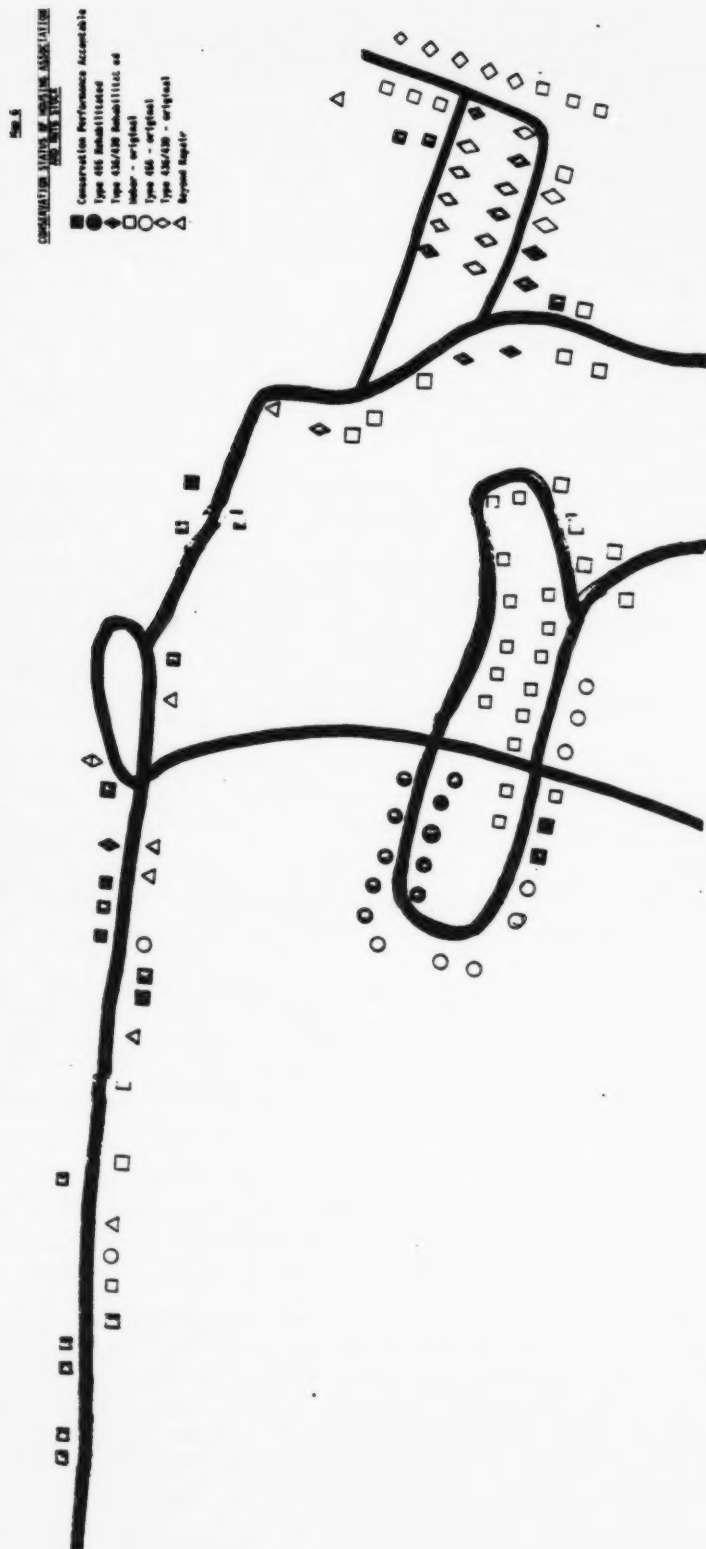
The distribution of housing stock types and the location of units for which rehabilitation or retrofit are completed, or slated, are shown in Map 6. In this map, the hollow symbols represent those units which have not been upgraded, and these are further categorized into: beyond repair, due for rehabilitation, due for retrofit. The solid symbols represent those units of acceptable conservation status, divided into: rehabilitated 436/439 or 455 types, Woolfenden houses. The remaining 10 Woolfenden houses were all constructed in 1979. They are all on full services and their conservation performance is regarded as 'acceptable'.

Table 5

SCHEDULE OF REHABILITATION AND RETROFITS FOR BUILDINGS
OPERATED BY THE HOUSING ASSOCIATION

Stock type and conservation status	UNITS PER YEAR								TOTAL
	81	82	83	84	85	86	87	88	
Matchbox: "Beyond Repair"	-----								9
436/439/455 for <u>Rehabilitation</u>	10	10	13	5	7	--	--	5	50
Weber: for <u>Retrofit</u>	--	--	--	10	12	8	6	6	42
Woolfenden "Conservation Acceptable"	-----								10

MAP 6



3.4 The Effects of the Housing Rehabilitation Program Upon the Unit and Overall Consumption of Energy

Table 6 shows the heating fuel and electrical consumption of the units covered by the rehabilitation program. The table is organized to show the difference before and after rehabilitation. However, before commenting further upon this, note should be taken of one apparent inconsistency within the table. The units listed for rehabilitation in 1982, mostly 455 types, would be expected to have a lower fuel consumption in the 1983 Petroleum, Oil and Lubricants Department records. This is clearly not the case, in fact, the rehabilitation process for this series of houses may take two years and the figures listed here in fact refer to consumption before rehabilitation. To check this, these figures were compared with those for 1981-82 and the similarities bear out this conclusion.

The most dramatic increase in conservation performance results from the rehabilitation of 455 units; with 436/439 types the increase in efficiency is more modest. In Table 7, these improvements are placed in the context of the conservation performance of other kinds of housing stock within the community. Here, the rehabilitation of a 455 type reduces annual fuel consumption from an average of 4,900 litres to one of 1,500 litres. For 436/439 types the comparable reduction is from 7,000 litres to 4,500 litres. This may be partly explained by the fact that 455 houses are a more recent design (See Table 1).

Table 7 also shows that rehabilitated 455 houses are the most energy efficient of all types, less than half the consumption of the current Woolfenden types. It should be noted also that, though the 436/439 types appear to be less responsive to rehabilitation, the resulting consumption is still lower than that recorded for Weber houses, a stock type that is not slated for rehabilitation but only for roof retrofit - which may at most reduce heating fuel consumption by 15%.

The data in Table 7 indicates an inverse relationship between the fuel and electricity consumption of houses, with the more energy efficient houses in general consuming more electricity. This relationship is graphically illustrated in Figure 3, in which housing units are classified into 10 consumption classes and further broken down in terms of stock types.

An exception to this tendency is the rehabilitated 455 type houses; in these, the electrical consumption actually declines compared with non-rehabilitated 455 stock. By contrast, the 436/439 types more than double electrical consumption after a rehabilitation.

The installation of major electrical appliances is usually thought to account for this increase in electricity consumption. Provision for this is part of the amenities component of the rehabilitation program, however, this does not help to explain the decrease in the electricity consumption of rehabilitated 455 houses - unless this part of the rehabilitation process has yet to be accomplished for those 455 houses

done in 1981. (Unfortunately supporting data on this could not be obtained from the Tahoonik-Sahoonik Co-operative, the organization executing the rehabilitations, due to a change in the staff managing the program).

When the costs of heating fuel and electricity are compared, some interesting results emerge. These are tabulated in Table 8 in terms of the average costs for each stock type. Not only does the quantity of electricity increase with improvements in energy efficiency, but the costs of that electricity begin to overshadow, by a considerable margin, those of heating fuel. For example, for the Woolfenden houses the average electricity bill is double the heating bill.

Of course, the cost of electricity to the householder does not reflect entirely the cost of the diesel fuel used to generate that power but also the costs of generation itself and of distribution. Though the Northern Canada Power Commission rates are confidential, a litre of diesel fuel is said to cost 38¢. Therefore, the fuel cost component of the 1,800,000 KWH's generated from litres is 15¢, and the production ratio is 2.6 litres/KWH. On this basis, the volume of generating fuel represented by the average electrical consumption of a Woolfenden house (13,400 KWH's per year) is 5,200 litres, still considerably higher than the average heating fuel consumption of this type (3,500).

Comparable figures for the 42 Weber houses in the community are 5,000 litres of diesel generating fuel, represented by an average electricity consumption of 12,700 KWH's per year, and an average heating fuel consumption of 5,100 litres per year.

These estimates lead to interesting conclusions vis-a-vis the objectives of the Remote Community Demonstration Program, as they relate directly to the consumption of oil, whether for space heating or electrical generating purposes. The changes in consumption patterns by 436/439 houses as a result of rehabilitation illustrates this question (see Table 7).

Before rehabilitation, the Weber house type averaged 7,000 litres in heating fuel consumption and 1,500 litres in generating fuel, for a total of 8,500 of both fuel types. After rehabilitation, the heating fuel decreased to 4,500 litres, but the generating fuel more than doubled to 3,200 litres, for a combined total of 7,700. In terms of total oil product consumption, the rehabilitation program has, according to these figures, achieved an apparent reduction of 9%.

Of course, a similar analysis of the rehabilitated 455 types recorded in Table 7 leads to an opposing conclusion. Yet such a conclusion would run counter to the prevailing view amongst officials of the Department of Public Works and the Housing Association; that rehabilitation programs tend to result in increased consumption of electricity. Unfortunately, there does not appear to have been a systematic analysis of this change in consumption patterns over all the communities where rehabilitation programs are in effect. The approximate results obtained here suggest that such an analysis might be of value in assessing the long term impacts of housing rehabilitation programs upon patterns of fuel consumption.

Table 6

ENERGY CONSUMPTION IN RELATION TO REHABILITATION PROGRAM

REHABILITATED				NON-REHABILITATED		
436	5.4	12.1	80	436	6.9	3.9
436	3.1	6.0	80	436	6.6	3.2
436A	5.4	6.5	80	436	6.9	5.5
436	5.0	6.5	80	436	6.8	4.7
436	4.1	6.9	80	436	6.1	2.9
436	3.8	5.1	80	439	7.8	3.2
436	3.7	8.3	80	436	6.0	8.8
439	5.2	7.9	80	436	7.8	2.9
439	5.3	18.8	80	436	5.5	5.7
439B	4.5	5.0	80	439	7.3	2.3
455	1.8	3.6	81	436	7.4	3.7
455	1.7	5.5	81	439	5.8	4.1
455	1.8	3.6	81	439	6.9	2.4
455	1.4	1.9	81	439	6.4	3.8
455	1.4	3.1	81	439	7.3	3.1
455	1.0	4.5	81	436	7.4	1.3
455	1.2	3.6	81	436	9.2	4.7
455	1.4	4.1	81			
455	1.7	3.4	81			
455	1.2	3.1	81			
436	7.7	4.6	82			
455	3.5	9.6	82			
455	5.9	6.7	82			
455	6.1	2.9	82			
455	5.3	5.1	82			
455	4.7	6.0	82			
455	3.5	13.2	82			
455	4.3	7.3	82			
455	4.7	6.4	82			
439	7.1	5.1	82			
439	8.0	5.7	82			
455	5.2	8.2	82			
455	6.0	7.5	82			

Table 7
AVERAGE HEATING FUEL AND ELECTRICITY CONSUMPTION BY HOUSING
STOCK TYPE

HOUSING STOCK TYPE	NUMBER UNITS	AVERAGE FUEL 1,000s litres	AVERAGE ELECTRICITY 1,000s KWHs
Matchbox	9	4.0	2.7
436/439 Non-Rehabilitated	20*	7.0	3.9
436/439 Rehabilitated	10	4.5	8.3
455 Non-Rehabilitated	10*	4.9	7.3
455 Rehabilitated	10	1.5	3.6
Weber	42	5.1	12.7
Woolfenden	10	3.5	13.4
NWTG Houses	12	3.4	11.0

*Includes houses slated for rehabilitation 82/83 but probably not completed.

Figure 3

COMPARISON OF HEATING FUEL AND ELECTRICITY BY HOUSING
STOCK TYPE AND CONSERVATION STATUS

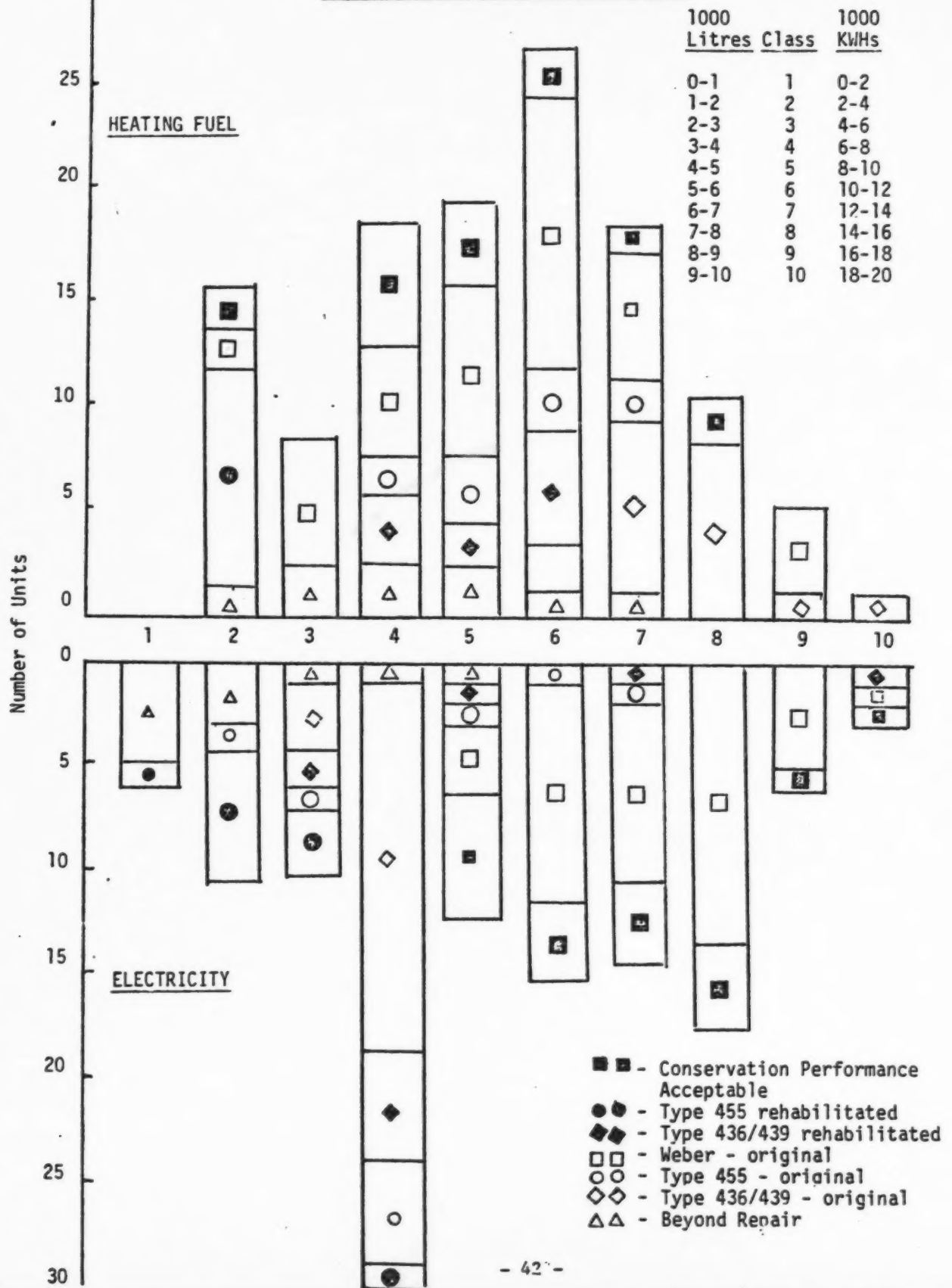


Table 8

COSTS OF HEATING FUEL AND ELECTRICITY BY HOUSING STOCK TYPE

Stock Type	Average cost of heating fuel 51¢ litre*	Average cost of electricity 31¢ KWH*	Average total energy cost \$	Total energy cost for all units of stock type
Matchbox	2040	837	3917	35,253
436/439 Non- rehabilitated	3570	1209	4779	81,243
436/439 Rehabilitated	2300	2573	4873	63,349
455 Non- Rehabilitated	760	1110	1876	18,760
Weber	2601	3937	6538	261,520
Woolfenden	1785	4154	5939	59,390

* Based on amounts paid by consumers who do not receive subsidies.

3.5 Projected Reduction in Domestic Heating Consumption Once the Rehabilitation and Retrofit Programs are Completed

In Table 9, the data tabulated in Tables 7 and 8 have been used as the basis for projecting the eventual reduction in heating fuel consumption that may be achieved once the current rehabilitation and retrofit programs are finished. The projected reduction in the total cost of heating the 42 Weber houses is based upon the 15% estimate provided by regional officials involved in housing and conservation.

The total estimated reduction is 116,000 litres (22%) for the 111 units under the jurisdiction of the Pond Inlet Housing Association. This total reduction amounts to 9% of the total community bill for heating fuel. The reduction is roughly equivalent to an average of 1,000 litres for each Housing Association unit. If this average were projected to the thirty houses under various other jurisdictions, which seem to vary as much in their conservation performance, the resulting reduction in the community heating fuel bill would be 146,000 litres, or 11%.

This reduction would to a certain extent be offset by an increase in the consumption of electricity in rehabilitated 436/439 houses but, apparently, not in the 455 types, and probably neither in the retrofitted Weber types.

A reduction of 22% in the total residential heating fuel bill would also be offset by increases resulting from a rise in the absolute number of housing units. Recent estimates of future housing needs that have been developed by the Hamlet Council suggest that this increase could be considerable.

At present the occupancy rate in the community is 4.7 persons per unit compared to 4.5 for the Baffin region, 4.1 for the Northwest Territories and 3.1 for the rest of Canada. Taking into account projected population growth to bring Pond Inlet into line with the rest of the Baffin region at 4.5 occupancy, 46 new houses would be required by 1989, (the final year of the rehabilitation and retrofit programs). This presents an increase of 32% over the total (142) number of residential units currently occupied in the community. If the community was brought to the Territorial level of occupancy, 65 new houses would be required - an increase of 46% over present stock.

It is highly likely that increases of this scale would completely offset energy consumption reductions of the scale estimated above. This conclusion coincides with the view of senior officials in the Regional Housing Association that the most that can be achieved through conservation programs is a levelling off of energy consumption.

Table 9

PROJECTED REDUCTION IN DOMESTIC HEATING FUEL CONSUMPTION
AFTER REHABILITATION AND RETROFIT PROGRAMS ARE COMPLETED

Housing Stock Type	Number of Units	Present Total Consumption of Heating Fuel	Total Consumption of Heating Fuel After Program
		1,000's litres	1,000's litres
Matchbox	9	36.0	36.0
436/439 non-rehabilitated	20	140.0	90.0
436/439 rehabilitated	10	45.0	45.0
455 non-rehabilitated	10	49.0	15.0
455 rehabilitated	10	15.0	15.0
Weber	42	214.0	182.0
Woolfenden	10	35.0	35.0
TOTAL	111	534.0	418.0

4.0 ENERGY ALTERNATIVES TO BOTH OIL AND COAL

4.1 Wind

According to a recent Science Advisory Board Report (1982) on the wind energy potential of the Northwest Territories, Pond Inlet lies within a region of "highly variable conditions". Though the settlement may experience periods of high-velocity winds that are essential for the production of energy from this source, in the terms of the Remote Community Demonstration Program, Pond Inlet is not a suitable candidate for demonstrating wind energy.

4.2 Natural Gas

There are proven reserves of natural gas in the central arctic islands. Apparent potential for producing condensates as a by-product of natural gas development is contingent upon major project initiatives on the scale of the Arctic Pilot Project. That project is currently in abeyance and there are no comparable efforts under consideration at present.

This situation could of course change swiftly, in which case the possibility of developing hydro-carbon supplies to arctic communities, as part of socio-economic development packages, could be examined. However, inquiries made to the major development interests revealed that there has been no concrete work in this area upon which to base any estimates of either cost or the technologies that might be required.

4.3 Slowpoke Nuclear Reactor

Inquiries at the Atomic Energy Commission have revealed that progress upon this technology has yet to proceed beyond the conceptual stage. That concept envisions the adaptation of a reactor now used for scientific research to the needs of remote communities. It is highly improbable that a reactor suitable for demonstration purposes will be developed during the time frame of the Remote Community Demonstration Program.

PART II
COAL DEVELOPMENT

1.0 INTRODUCTION TO PART II

The purpose of this part of the study is to discover whether the technical and economic conditions affecting community coal utilization are promising enough to justify a thorough inventory of accessible coal reserves, and the subsequent development of a design study.

However, to a certain extent, conclusions on these technical and economic questions are contingent upon there being sufficient quantities of suitable coal to supply Pond Inlet for a period that can compensate for the costs of conversion from oil to coal as the primary energy source for space heating and/or the generation of electricity. As a very rough guide, it has been estimated that a total volume of 200,000 tons of all coal would be required over the next twenty years. This estimate was developed by converting current volumes of diesel and heating fuel to coal equivalent volumes.

On the assumption that coal reserves are both sufficient and a suitable quality, certain estimates can be made about the likely methods of production and conversion, the resulting environmental impacts, and the socio-economic effects of coal development. However, final assessments of the feasibility of one coal conversion process or another cannot be made until more is known about the characteristics of the coal reserves. In this respect, sulfur content is one of the most significant factors, with a critical bearing upon the technical and economic feasibility of coal development. With these reservations in mind the following discussion will focus upon two objectives: first, to develop a set of the most likely coal development scenarios, which may serve as a framework for evaluating the data yielded by an inventory of the coal reserves, and second, to come to those conclusions which can be reached on the basis of available information, while at the same time eliminating the most impracticable courses of action.

At present, two principal conditions appear to exert a general and limiting effect upon the course of coal development. The first concerns the economy of scale energy production from coal, where the unit cost decreases substantially as the energy output increases. This argues in favour of using coal generated electricity for as many purposes as possible, even domestic space heating. It argues against pursuing separate lines of development which may eventually conflict, for example, developing a capacity for coal-generated electricity while at the same time introducing coal-fired furnaces for space heating.

The second condition becomes operative if a decision is made in favour of developing a coal generating capacity; should the power station be located at the mine site or in the community? Obviously, in the former case, there would be no scope for district heating. Both these conditions will be further discussed in the chapter dealing with coal development scenarios. Leading towards that direction the following discussion will examine the various phases of coal development.

2.0 INVENTORY OF COAL RESERVES

2.1 Geological Surveys

While this study was in progress, a series of proposals and work statements for an air/ground survey and drilling program were developed. These define the logistical and technical problems involved in a coal reserve inventory.

As the research into possible coal conversion technologies proceeded, and as a result from casually examined samples arrived, it became increasingly likely that a local geological survey would also need to locate sources of limestone - for application in the control of sulfur emissions. The precise quantities of limestone would depend both upon the qualities of the limestone itself and the sulfur content in the coal. A review of the limited geological literature available on the Pond Inlet area indicated that occurrences of limestone are rare, with the documented examples located at considerable distances, both from the settlement and the principal coal seams at the Salmon River.

2.2 Results of Previous Analyses of Coal Samples

Coal samples from the Salmon River deposits have been analysed on various occasions since 1924, when the Hudson's Bay Company began to mine about 50 tons a year under lease. The most recent analyses were of coal from the outcrops near Tuniaqtalik Point, taken in the course of this study.

The results show the coal being variously classified as: sub-bituminous B, sub-bituminous C and lignite A. Sulfur content varies considerably, from 0.4 to 3.2 (as received) and 0.4 to 4.3 (dried); however, most of the sulfur analyses reveal a level below 2.0, whether as received or dried.

The results of these analyses have been included as Appendix 2*, since they were taken over such a long period, and cannot be regarded as elements of a systematic appraisal of the reserves. The results should not be applied in a serious evaluation of any coal conversion technologies. However, they may have some general value as indicators in the event that an inventory of the reserves takes place following this study.

3.0 COAL EXTRACTION METHODOLOGY

In the view of the Petro-Canada coal exploration staff, who drilled one core at the Salmon River deposit in 1981 (see Appendix 2*), this reserve could be simply mined by an open-pit operation, assuming the seams remained as close to the surface as they are at the drill-site.

The previous method of obtaining coal was simply to collect it directly from the seams exposed at the cliff face, a task that can only be accomplished while the river is frozen. However, for a long-term, larger-scale, operation, this approach would not be acceptable as the community is concerned that the Salmon River not be contaminated by a mining operation directly along its banks. However, if the coal deposits exposed here are to have any long-term potential, they will extend away from the river and provide scope for an extraction operation which could leave the river bed and immediate banks intact.

On the matter of extraction technique, local Departments of Public Works staff have had considerable expertise with quarrying gravel in areas close to the settlement. Based upon this experience, they suggested that a back hoe, equipped also with a loader and a blade, would be capable of moving the overburden and separating the coal from the inter-seam material which is primarily sandstone. This equipment has proved to be adequate when working in permafrost, but may occasionally have to be supplemented with blasting.

As a very rough estimate of the annual amount of coal that would be required to displace Pond Inlet's consumption of generating fuel, the figure of 10,000 tons was generated, based on an average consumption of 1 ton per hour. If the coal mine was to be worked all year (50 weeks of five working days each) 40 tons would have to be made available for transport each day. The backhoe suggested by Department of Public Works staff (caterpillar 235 on tracks) is capable of shifting 20 - 30 tons a day on quarrying operations. Assuming that a certain amount of unusable overburden would also have to be shifted, it seems that two of these machines would be required to provide an adequate supply of coal.

Assuming a total operating cost of \$100/hour for these machines, their total annual operating cost would be \$200,000, or \$20 per ton.

4.0 COAL TRANSPORTATION

Coal from the Salmon River was originally delivered to the settlement by dog-sled and more recently by snowmobile. Transport of large quantities by water would be impracticable, for though the river is quite deep where the exposures occur, at its estuary the water is too shallow to permit even the passage of a freighter canoe.

During the field work phase of this study, two traverses between the settlement and the Salmon River deposits were made on foot.

The more inland route was taken initially in the expectation that the upland terrain would prove to be drier and the stream crossings less of an obstacle than along the return route, closer to the coastline. Though this was generally the case, the advantages did not appear to be so great as to compensate for the greater distance taken on the inland route. In this preliminary assessment, the direct route seemed to possess the overall advantage. The characteristic terrain and stream crossings in the area suggest that neither of these present serious obstacles to the construction of an all-weather road that could be used for transporting coal to the settlement.

Again, the Department of Public Works staff in Pond Inlet were helpful in providing rough estimates of the time and cost involved in constructing such a road. It was felt that the road could be built with the equipment already based in the settlement; that construction would take about two months and would cost in the region of \$50,000.

For coal delivery, it was suggested that 5 ton trucks, of the kind already used in the settlement, would be suitable. Based on an annual requirement of 10,000 tons to displace currently consumed generating fuel (see page 7-5), two such trucks would probably be sufficient. In fact, assuming that the turn around time for a delivery journey of 10 km each way plus loading and unloading would be an hour, the 40 tons per working day requirement could be delivered by a single truck; however, it is unlikely that truck travel could easily be maintained throughout the year and therefore two are suggested as more suitable.

The Department of Public Works provided very rough estimates for the costs of operating and maintaining two 5 ton trucks. These could amount to \$25,000. per year for each truck, plus perhaps the same amount as driver's wages. This would total \$100,000. per year for coal delivery, or \$10. per ton (this figure excludes amortization and capital costs of equipment).

Combined with the rough estimate of \$20. per ton for producing coal, a total of \$30. per ton is reached for delivery to the community. This figure does not take into account amortization costs, or other costs of mining, such as waste disposal and restoration, neither does it include the costs of coal preparation. However rough, it may be compared with a frequently quoted consumer price of \$100. per ton for good coal in southern Canada.

5.0 COAL COMBUSTION TECHNOLOGY

5.1 Introduction

The technologies that have been reviewed may be put to the following variety of purposes:

1. Heating individual buildings with hot water systems. (combustion system + boiler + circulation system).
2. Heating individual buildings with hot air systems (combustion systems + heat exchanger + circulation system).
3. Providing heat source for several adjacent buildings (combustion systems + boiler + district heating system).
4. Electrical power generation (combustion system + steam raising system + steam turbines to produce electricity, with gas turbines as possible addition).
5. Electrical power generation plus a district heating system (combustion system + steam raising system + steam turbines + waste heat district heating system).

All of these areas are currently subject to intensive research and development. This is producing technologies with commercial applications in the first three of those listed above, but, in the area of electrical generation, the present effort is on a far larger scale than that required by Pond Inlet. However, there are indications that, within a few years, power generation on a more suitable scale may become feasible.

As an alternative to using coal directly as the energy source, it may be first converted to another form, through either a gasification or liquifaction process, or through mixing with certain liquid fuels. These prospects were discussed with researchers at CANMET, the National Research Council and the Coal Research Establishment (UK). The general view was that these technologies would not be applicable in the case of Pond Inlet.

The small-scale gasification processes that are in commercial operation produce a low BTU gas that is more appropriately used for certain industrial purposes. Liquifaction remains an expensive alternative to natural liquid hydrocarbons, even when produced on a very large scale. Coal-oil mixing, besides, being still at the experimental stage, requires expensive and sophisticated coal preparation equipment.

The same researchers felt that, if the generation of electricity from coal should prove to be feasible, then attention should be focused on two technologies: 1) Fluidized bed combustion, a fairly recent development, and 2) Conventional stoker technology, and its current refinements. Development in both these technologies is so rapid at

present that researchers felt that options should be kept open as long as possible, at least until the qualities of the coal reserves had been ascertained.

On the basis of these expert opinions, the following discussion will focus upon these two options as far as the generation of electricity is concerned. However, it should be noted that either fluidized bed combustion or stoker technology could be used as the combustion unit either for heating a large building or for district heating, without any consideration of generating electricity.

Generally though, the units used for heating individual buildings are more simple in conception and operation than those designed for power generation. However, they have by no means been neglected in current research and development, particularly in Europe. There, the effort has been towards increasing the efficiency, reducing the risk of operation, and attaining a level of automation comparable with oil-fired units.

In the following sections, advances in three areas will be reviewed in turn: 1) individual heating units, 2) fluidized bed technology, and, 3) conventional stoker technology.

5.2 Coal-Fired Space Heating

Most adults in Pond Inlet have had some experience with coal stoves and furnaces. This is not necessarily an advantage as far as this project is concerned as the general recollection is of comparatively inefficient, occasionally hazardous and smelly units, usually in need of frequent attention.

This view is perhaps not entirely absent in southern Canada. However it has not prevented some householders in areas where coal is plentiful and cheap, from converting to some of the more advanced units which have recently come on to the market. But, these also tend to require rather more care than oil-fired furnaces; the compensation for the extra trouble lies in reduced household energy bills.

There is no comparable inducement in Pond Inlet. All domestic heating costs are subsidized to some extent, with consumers either enjoying complete relief or paying an amount related to the total household income. Even those paying the maximum (about \$400./month for all utilities) would not gain any relief from a switch to coal under the present system as their payments remain the same regardless of the level of consumption. These two factors, plus a history of inefficient coal utilization coupled with a lack of incentive to individuals to revert to coal should be considered in contemplating any changes in domestic space heating technology.

Having said that, perhaps a distinction could be drawn between the general lack of incentive with regard to domestic housing units and the varying degree of incentive associated with buildings that are used for various governmental functions or for commercial purposes. In such cases a deliberate policy of energy conservation, or a budgetary

necessity may achieve the same effect as a personal incentive. In Pond Inlet, the Tahoonik-Sahoonik Inuit Co-operative has already expressed interest in coal-fired units which would provide relief from the full heating oil costs that the organizations must bear.

This distinction also corresponds to the two major categories of coal-fired heating units reviewed during this study. On the one hand there are the refinements of more or less traditional furnaces and stoves, which would be most suitable for domestic heating; on the other, there is a range of larger units suitable for heating small plants and office buildings. Some of these are entirely new designs incorporating sophisticated principles such as fluidized bed combustion, automatic stoking and control through micro-processors.

The designers of these new and improved types of coal-fired heaters have acknowledged that they must compete with other types, not only in terms of reduced energy costs, but also with respect to ease of operation. Thus, the emphasis upon automatic stoking and control systems. One particular model, the Holden Heathouse, was examined while in operation at the Coal Research Establishment in England. It has many of the major advances that have been achieved in such designs, automatic fuelling and de-ashing, a bunker that will hold several days supply of coal, and automatic flue cleaners. The Holden Heathouse is designed for a hot water circulation system. Holden Heathouse also have units with a 25-60 KW range that are designed with large houses, farmhouses, shops, and small workshops in mind. However, once the development is complete, commercial units of up to 300 KW may be manufactured which employ the same operating principles and features. Units of such capacities could be used to provide heating for some of the larger buildings in Pond Inlet.

The Coal Research Establishment is experimenting with adapting fluidized bed combustion to such relatively small scale capacities, but have not yet developed a prototype. However, researchers at the Centre for Energy Studies of the Technical University of Nova Scotia have developed a small prototype fluidized bed combustion unit. This unit has been tested for a year, attached to a forced air furnace in a conventional private house. A description of this trial is attached as Appendix 3.*

Though this unit is small, the researchers responsible for its development feel that, once its commercial feasibility has been established, the unit could easily be increased in capacity to heat small factories, schools, and hospitals. The prototype inspected in the course of this study was being charged with a coal-water mixture at that particular time but has also been satisfactorily fed with various grades of crushed coal.

The coal Research Establishment is currently working on the development of two coal-fired warm air heaters. A 10 kw unit provides a supply of hot water for domestic use, but is batch fed, requiring regular attention. The other unit producing 4 Kw has two additional features, an automated grate and an automated coal feeder. The coal feeder is regulated by a bed level sensor.

Neither of these heaters have forced air circulation systems. This arises from a general concern in England that fan-driven air from coal heaters increases the CO hazard beyond acceptable levels. Though some of the researchers at the Coal Research Development feel that recent advances in control and contingency systems have rectified this problem, they still acknowledge that the generally negative attitude persists and have therefore concentrated upon the optimum development of "natural-draught" circulation systems.

This had led to the design of a complete house around a coal-fired heating system based upon the natural circulation of warm air. Such an approach could well be worth consideration in Pond Inlet. The secretary of the community Housing Association was asked for his views upon ways of overcoming local resistance to a reversion to coal. His suggestion was that a safe and efficient house, designed to optimize coal energy be produced as a demonstration project.

A coal stove has been designed to compete with wood-fired room heaters. A feature not often found on the older types of coal stove is the secondary combustion process designed to reduce emissions by burning off volatiles produced during the primary combustion process. Stoves such as these perhaps approximate, in function at least, those which would have been used in Pond Inlet before oil was introduced. They might nowadays be useful in small one-room workshops or in outpost camps.

This brief review of current research and development in coal-fired heating systems for individual buildings leads to several promising conclusions. From the technical perspective, issues arising from inefficiency, hazard and the need to constantly attend coal units could probably be resolved by taking advantage of current developments. The ground appears to be well prepared for developing a local trial designed to overcome local resistance as well as demonstrating economic potential relative to heating oil.

5.3 Combustion Systems for Generating Electricity from Coal

Experts from the Canadian Centre for Mineral and Energy Technology and the Coal Research Establishment were asked what they felt, in their experience, were the prospects for converting from diesel fuel to coal for generating electricity. There was common agreement amongst the research scientists consulted, that, 1) the scaling down of current systems to meet Pond Inlet's needs would be prohibitively expensive, but current research and development could, within a few years, lead to the production of commercial systems suitable for the community, 2) assuming such technology was available, the selection of the most appropriate

system must await the comprehensive evaluation of the coal reserves, and 3) that the most likely final choice of technology would lie between fluidized combustion bed systems and conventional stoker systems.

A third combustion process, not mentioned by all those consulted, is pulverized firing, in which finely ground coal is blown into a combustion chamber and ignited in much the same way as fuel oil. This process is common in the large-scale generation of electricity. In Canada, a current research and development effort is directed towards a variant of pulverized firing, limestone injected multistage burning (LIMB). Applicable results from this program could emerge in 1984. Technically, pulverized firing might prove suitable for Pond Inlet; the crushing and sorting systems that are required to prepare coal for this process are rather expensive.

To illustrate the range of combustion alternatives, a number of photographs and summary descriptions are attached as Appendix 4.*

The most likely total generating system would use the combustion technology to raise steam that would be used to drive a turbine to produce the electricity. Some systems would provide for using the hot coal gases to drive gas turbines, separately or in conjunction with the steam turbines.

5.4 Stoker Technology

Stoker technology has been the traditional process of coal combustion for a considerable period and, though it may be less advanced than fluidized bed combustion in certain respects, is still in common use and is the subject of certain research and development programs designed to introduce refinements. In England, coal stokers that were converted to oil, when that became cheap and readily available, have recently been converted back to coal burning.

In the course of this study, it was suggested that the community explore the possibility of acquiring a 'second-hand' stoker from areas such as the Maritimes or the Prairies, where small scale coal stoker facilities were once far more common than they are now.

*Conservation & Renewable Energy Office, EMR, has copies of appendices
P.O. Box 68
Yellowknife, N.W.T.
X1A 2N1

The main advantage of stoker technology is that the process is simple and well-proven. However, the traditional technology is not well-equipped to reduce sulfur during combustion and, for this, expensive scrubbing systems would have to be added. Emission control would also require the addition of limestone as well as introducing a problem of sludge disposal. It is in this context that the aforementioned limestone injected multistage burning process might prove to be a more efficient alternative.

5.5 Fluidized Bed Combustion

Fluidized bed combustion is the subject of intensive research and development efforts, both in Canada, Europe, and the United States. The principal advantages of this process are that:

- low or mixed grades of fuels can be burnt efficiently
- high heat production compared with other systems allowing greater operating economy
- inherent capacity, with additions of limestone or dolomite, to reduce sulfur emissions
- provide scope for generating electricity with gas turbines as well as steam turbines

For a summary discussion of operating principles and illustrations for fluidized bed combustion units, the reader is referred to Appendix 4.*

Projections of the comparable costs of large-scale units suggest that fluidized bed combustion units may cost less than the combined costs of stokers and scrubbers. However, for certain types of fluidized units crushing and cleaning technology would be required to prepare the coal.

Fluidized bed combustion units may operate at atmospheric pressure or be constructed to operate at higher pressures. There are several advantages to pressurized fluidized bed combustion as far as the generation of electricity is concerned.

- emissions are further reduced
- fluidization is more efficient
- hot pressurized off-gas may be used to drive gas turbines to produce electricity.

The development of such fluidized combustion systems is still in the experimental stages and three combustors, in the range 1 - 4 MW are currently undergoing trials in the United States (see Appendix 5).

In Canada, the Summerside Fluidized Bed Combustion Generating Station is already in operation. Small by current standards, this facility still produces more than double the projected needs of Pond Inlet for thermal and electric power at a cost of \$13.5 million to construct.

To provide an impression of the current range of uses to which fluidized bed combustion units are currently being put, a listing of about 50 units currently in operation in Europe and North America has been attached as Appendix 5.* It may be noted that many of these are described as being for 'demonstration' or 'developmental' purposes. Though only a few are operated to produce electricity, several are used as the heat source for district heating systems and an encouraging number have outposts in the range required by Pond Inlet.

Though fluidized bed combustion may reduce sulfur and other emissions with greater efficiency than other systems, this process still requires the addition of limestone. The quantities of limestone needed depend upon the sulfur content of the coal and cannot be estimated for Pond Inlet until the quality of the coal reserves has been determined.

6.0 ENVIRONMENTAL IMPACTS OF COAL DEVELOPMENT

In the foregoing, frequent allusions have been made to the problems of controlling sulfur emissions and the waste products of coal combustion, principally ash and clinker. Each of the coal combustion technologies discussed produces specific environmental impacts. To these should be added the impacts of mining the coal itself, transporting it to the community and storing it.

None of these impacts can be described in sufficient detail for satisfactory assessment until more is known about the coal qualities, the most efficient method of mining, and the combustion method which will prove to be most effective from the technical and economic viewpoints.

However, environmental impacts will have a definite bearing upon the selection of the most suitable systems and should be added to technical and economic factors in making this evaluation. There is also a social dimension to the identification and evaluation of impacts which will be taken into account during the field work. For example, there may be a preference for a coal generating station located at the mine site rather than in the community, or an aversion to installing coal-fired burners in homes.

To assist in identifying areas of impact, an environmental impact matrix has been developed and reproduced as Figure 4.

Further details on these provisional impacts are provided below:

1. At the Coal Mine Site

The major impact would be erosion resulting from the open-cast mining operation. To minimize this, drainage control, in the form of weirs, catchment areas, dams, etc., would be required. The most effective method for controlling local environmental impacts would be to accompany the mining process with one of progressive restoration. This would entail the pre-determination of eventual contours, as a result of the removal of bulk material, and the replacement and re-planting of the overburden as mining proceeds. The environmental impact statements accompanying arctic pipeline proposals contain comprehensive statements on the methodologies for restoring arctic terrain types and the success that may be achieved with the various indigenous plant species.

There may be a need, at the mine site, for a lagoon in which to treat and settle waste waters, or those which may arise in the workings. It would be especially important to prevent contaminated waters from entering the Salmon River. As the visible seams, and their immediate hinterland, lie within the watershed of the Salmon River, this impact management measure requires careful attention.

Depending upon the qualities of the coal, and the mining method employed, there may also be a need to implement dust suppression measures at the site.

2. Coal Storage

If coal is to be used extensively within the community, a stockpile of a certain size would be required. A major objective in stockpiling coal is the prevention of spontaneous combustion and a strict program of thermal monitoring would be required. The actual method of stocking, whether air is entirely excluded or the pile is completely ventilated, would depend upon the quality of the coal and the kind of coal preparation that may be required.

A storage site would be needed, on a firm, level or gently sloping base, either of gravel or concrete. On the assumption that the most that need be stored would be three month's supply (2,500 tons), this amount would probably require an area 40 m square, with a pile of 3 m in height.

3. Ash, Clinker and Sludge Disposal

The precise volumes of these wastes that may be generated would depend to a large extent upon the qualities of the coal, the coal preparation method used and the combustion method. For the most part, these wastes would have to be removed to a suitable storage site outside the community; however, there may be some scope for using certain of these materials, for example, clinker for fill or the top-dressing of roads.

Figure 4

PRELIMINARY ENVIRONMENTAL IMPACT MATRIX FOR POND INLET COAL DEVELOPMENT OPTIONS

SOURCE OF IMPACT	AREA OF IMPACT	LAND	WATER	AIR
COAL MINE		Erosion during excavation. disposal of overburden	Impact on local drainage sedimentation fuel oil spills	coal dust emissions from excavation equipment
COAL TRANSPORT		road construction and operation	stream crossing of road	coal dust en route
GENERATING STATION AT MINE SITE		construction phase ash, clinker and/or sludge disposal	water supply needed for generation process disposal of used waters	emissions from combustion process
POWER LINE TO POND INLET		Physical impact of right of way and service road obstacle to wildlife	stream crossings	--
GENERATING STATION IN POND INLET		construction phase ash, clinker, and/or sludge disposal	water supply needed for generation process. disposal of used water	emissions from combustion process dust from stored coal
DISTRICT HEATING SYSTEM		heating conduits obstructing other infra-structural elements	--	--
HEATING OF INDIVIDUAL BUILDINGS		multiple sources of ash/clinker waste fire/CO hazard	--	multiple sources of emissions

7.0 THE SOCIO ECONOMIC COST/BENEFITS OF COAL DEVELOPMENT

Until this point in the study, the discussions have been dominated by technological, economic, and environmental considerations. However, once the most impracticable options have been eliminated, those remaining may be presented as several conservation and coal development scenarios. These will take into account the priorities of the Hamlet Council, for example, that coal development increase the economic independence of the community as a whole and that as many jobs and small business opportunities as possible are integrated into a coal development plan.

In Table 10, a first approximation is provided of the kinds of work that might be associated with the various conservation and coal development options. In evaluating these options; a complex and wide range of factors must be taken into account; whether for instance, money, in the long-term especially, is spent within the community or whether it is spent upon imported goods and labour. For example, a district heating system based upon diesel generation may appear economically and technically more efficient than using coal but if the margin is very narrow, then a coal based system may be preferred as the money spent upon coal production would be spent more within the community.

As another example, space heating with electricity may at present cost more than using imported fuel, but the production costs of coal, and the volumes available may justify this approach.

A generating station which supplied energy for both heat and electricity would consume the highest quantities of coal and would perhaps provide more long-term jobs than any other approach. If this station was located at the mine site, environmental impacts in the community, and from a coal transport system would be minimized.

In Sections 7 and 8 reference was made to the kinds of tasks and equipment which would be involved in the production and transportation of coal. These fall generally into two categories: 1) heavy equipment operation, and 2) supporting skills and expertise.

Heavy equipment includes bulldozers, back hoes, and dump trucks. Qualified operators of such machinery can already be found in Pond Inlet.

The more specific skills required in coal production include: blasting, grading, landscape restoration and managerial posts. For these, training would be required.

Coal combustion would call for a still further set of fresh skills: the operation of generators, coal furnace installation and maintenance.

Until a commitment is made to a specific form of coal utilization, only the most general estimates of the number of jobs entailed could be made. However, on the scale of 10,000 tons per year, perhaps production and transportation might call for 6 - 8 man-years, while the operation and maintenance of coal combustion systems, for heating and generating, might provide an amount of employment equivalent to that currently related to oil utilization.

TABLE 10

EMPLOYMENT PROSPECTS IN RELATION TO VARIOUS COAL DEVELOPMENT
AND CONSERVATION OPTIONS

PROCESS	RESULTING WORK/EMPLOYMENT
Rehabilitation and retro-fitting of buildings	Short-term construction and carpentry
District heating system, with diesel or coal	Short-term construction followed by some maintenance With coal as the energy source, this would entail coal mining and delivery to a community generator
Coal heating for major consumers	Coal mining and delivery (long-term) Ash clinker collection (long-term) Furnace maintenance and operation (long-term)
Coal generating station in hamlet, electricity and for heating	Coal mining and transport (long-term) Operating generating station (long-term) Ash/clinker/sludge disposal (long-term)
Coal generating station at mine site, supplying electricity for heat to hamlet	Construction of station (short-term) Coal mining (long-term) Operating generating station (long-term) Ash/clinker/sludge/disposal (long-term)

8.0 COAL DEVELOPMENT SCENARIOS

The various options discussed in the previous chapter could be combined in several permutations to produce a series of coal development scenarios. Though these could not lead to any firm conclusions until the results of the coal inventory have been obtained, they would be of use in planning a design study. Such scenarios would consist of elements of three main sets of options:

1. Power Generation
 - 1a. Retain diesel generators
 - 1b. Coal generation in Pond Inlet
 - 1c. Coal generation at mine site
2. Heating Systems
 - 2a. Direct coal heat
 - 2b. Coal generated waste heat
 - 2c. Coal generated electric heat
 - 2d. Diesel generated waste heat
3. Categories of Building Heated
 - 3a. Minor buildings (mostly houses)
 - 3b. Major buildings
 - 3c. All buildings

Theoretically, these options could be combined in 36 different scenarios. However, many of these are impracticable or contradictory and, for a preliminary review, five of the most likely have been listed below.

1. Retain diesel generation and use coal heat for:
 - all buildings, or
 - minor buildings, or
 - major buildings.
2. Retain diesel generation with waste heat to major buildings and coal heat in remaining buildings.
3. Coal generation in Pond Inlet with waste heat to major buildings and coal heat in remaining buildings.
4. Coal generation in Pond Inlet with electrical heat to all buildings.
5. Coal generation at the mine site with electrical heat to all buildings.

Scenarios 3, 4, and 5 would entail considerable expense and, in the common view of the experts consulted, could probably not be contemplated until a few years have elapsed and suitable technology has been commercialized. Moreover, supplying electrical heat to all buildings would entail considerable expense in adapting the electrical and heating systems in place.

One exception to this general conclusion might be considered if the coal reserves prove to be low enough in sulfur content to allow the use of a conventional stoker system without expensive adaptation. In such a case it may be worthwhile attempting to purchase an existing facility that is no longer in use.

In terms of what could be achieved most expediently and immediately, scenario 2 represents perhaps not only the most practical approach from a technological perspective but also the one which might present the greatest savings in terms of the amounts invested. Amongst those buildings not heated with waste heat, major consumers would be dealt with first.

It appears likely that a district heating system could be directed to one sector of the community and provide heat for several of the heaviest consumers. But this would still leave several major consumers in more isolated locations, for example, the community hall, or the Tahoonik-Sahoonik Co-operative. Heavy consumers, such as the Royal Canadian Mounted Police complex, which divides consumption amongst a cluster of offices and houses, might benefit from mini-district heating systems based upon one centrally placed furnace.

By dealing with major consumers first, not only would the highest return on investment be obtained, but an opportunity would be provided to demonstrate to residents the efficiency, reliability, and security of current coal-based systems. A successful demonstration should be a pre-condition for converting from oil to coal in private housing.

Therefore, pending the emergence of electricity generating technology on a scale suitable for Pond Inlet, the following sequence is suggested as the most promising approach to reducing oil consumption using available technology. The first of these stages could get underway before a reserve assessment is undertaken.

1. Determine the optimum route for a district heating system based upon diesel-generated waste heat.
2. Review the heating requirements and records of those major consumers not included in the above system.
3. Execute a more detailed survey of the coal conversion devices on the market which would have the capacity to supply heat to the major consumers.

4. Investigate the possibility of single consumers with clusters of buildings, Royal Canadian Mounted Police, Co-op, using a coal conversion unit as the basis for a mini-district heating system.
5. Prepare project development estimates for selected buildings: Quantities of coal required, installation and operating costs, etc. It is conceivable that at this state, only 5 - 10 consumers would be under consideration.
6. Select the most appropriate buildings, or groups of buildings to demonstrate these systems.

9.0 THE SCOPE FOR INFORMATION TRANSFER OF THE RESULTS OF THIS STUDY TO OTHER REMOTE COMMUNITIES

The results of this study may be applicable in two areas, depending upon the extent to which conditions elsewhere resemble those in Pond Inlet. These are, in the effects of energy conservation programs, and in coal combustion technology.

The analyses in Section 3 - 4 suggested that the rehabilitation program, for certain types of housing stock, may reduce heating fuel consumption by a considerable margin, but may at the same time lead to an increase in the consumption of electricity which effectively cancels this advantage. This result may be of particular significance for those Remote Community Demonstration Projects aimed at displacing generating rather than heating fuel. Where a rehabilitation program is in progress, or contemplated, or where new housing stock is being introduced these might have unexpected effects upon overall consumption patterns of oil products.

In the second area of potential information transfer, the data obtained from the Coal Research Establishment on the current generation of automatic coal heating systems (Section 9-2) may have application in most remote communities with access to coal. The buildings which were recommended in this study as candidates for demonstration projects are of a type to be found in many northern communities.

LIST OF APPENDICES

- APPENDIX 1: DOCUMENTS RELATING TO COAL EXPLORATION PROGRAM
- APPENDIX 2: RESULTS OF ANALYSES OF POND INLET COAL RESERVES
- APPENDIX 3: OPERATING ACCOUNT OF A SMALL SCALE FLUIDIZED BED COMBUSTION UNIT
- APPENDIX 4: PHOTOGRAPHS AND SUMMARY DESCRIPTIONS OF COAL COMBUSTION TECHNOLOGIES
- APPENDIX 5: LISTS OF FLUIDIZED BED COMBUSTION SYSTEMS AND THEIR APPLICATIONS, THAT ARE CURRENTLY IN OPERATION

The appendices are available on request from:

Conservation and Renewable Energy Office
Energy, Mines and Resources Canada
4922-52nd St., 10th Floor
Yellowknife, N.W.T.
X1A 2N1

(403) 920-8475
Zenith 06068 (toll-free)